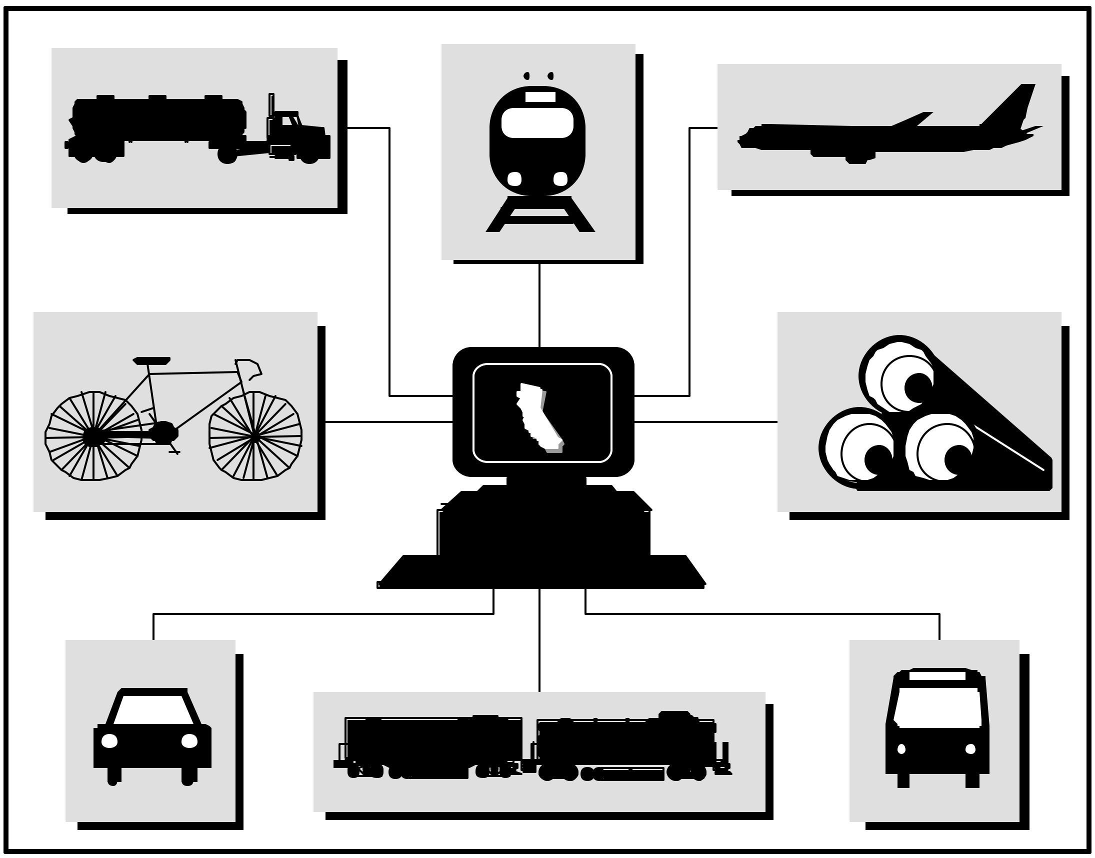
CALIFORNIA INTERMODAL TRANSPORTATION MANAGEMENT SYSTEM (ITMS)

prepared for

California Department of Transportation

ITMS BASIC DOCUMENTATION



prepared by

Booz·Allen & Hamilton Inc. Team

May 2001

1. OVERVIEW

The California Intermodal Transportation Management System (ITMS) is designed to provide a quick-response statewide sketch planning tool to assist planners in evaluating proposals to improve investment decisions. It provides the capability to analyze the current transportation network and to evaluate the impacts of investment options at the corridor, area or statewide level. The ITMS framework highlights intermodal tradeoffs by basing analyses on demand by market segment. Specifically, these include:

- Person Travel
  - metropolitan local travel (auto, bus, rail)
  - non-metropolitan local travel (auto, bus)
  - intercity travel (auto, bus, rail, air)
  - international travel (auto, air, vessel)
- Freight Transportation
  - urban goods movement (truck, van, rail)
  - intercity freight movement (truck, rail, air, barge, pipelines)
  - international freight / goods movement (vessel, air, truck, rail).

To support the individuals who will be working with the ITMS, two volumes of documentation have been prepared:

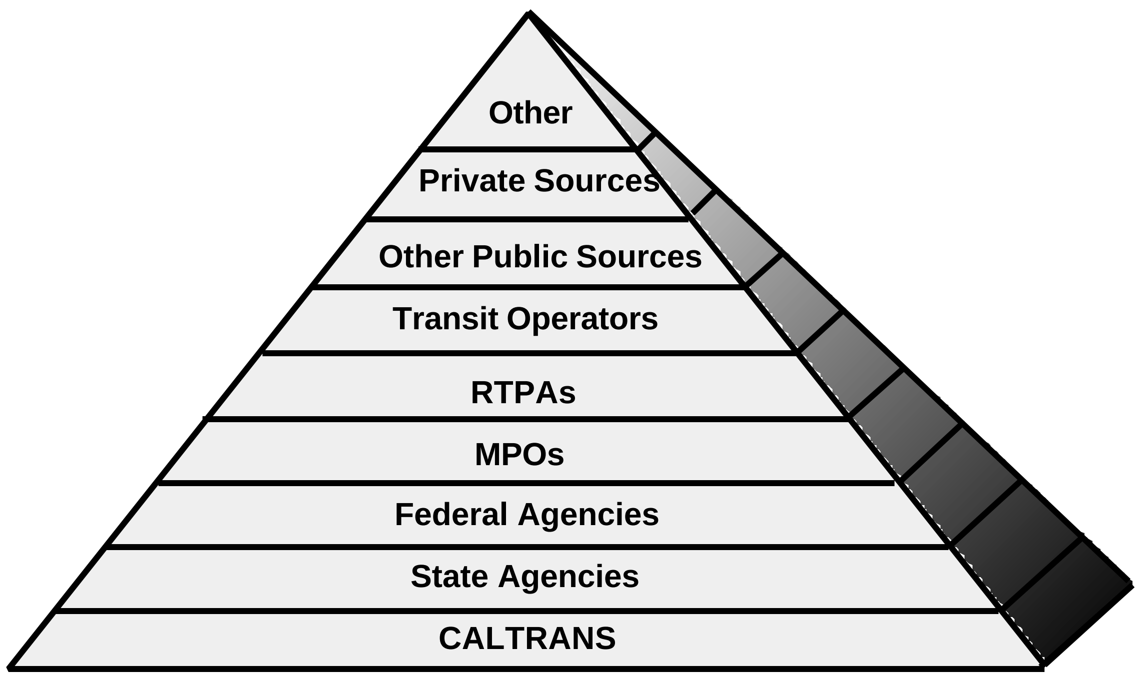
- Basic Documentation
- User Guide.

This is the “Basic Documentation” volume, which identifies the sources of data and the processes / tools that were used to develop the ITMS database. It also discusses the analytic capabilities (i.e., demand models and performance measurement) contained within the ITMS.

The other document, the User Guide, is an introductory volume that guides the user through installation of the ITMS and its graphical user interface. The User Guide also includes a data dictionary, or key, for the modal network and facility fields.

The available sources of data may be represented as a pyramid, as shown in Exhibit 1-1, with the broadest primary data available from those agencies depicted at the bottom and more specific primary and secondary data available from organizations named at the top. To the extent possible, the ITMS relies first on data collected within Caltrans. For data not available within Caltrans, other state and federal agencies, MPOs, RTPAs and transit operators were approached. Where necessary, other public and private sources were identified and used. For example, the proprietary TRANSEARCH database was purchased for goods movement because it is the most comprehensive source of commodity flows on highways and rail.

Exhibit 1-1
Data Hierarchy



The basic documentation provided in this volume has been written as a reference tool for people who will be responsible for maintaining, updating, and using the ITMS. As a result, it is factual and descriptive, but no effort has been made to enhance its presentation.

Data sources and processing procedures for the following areas are covered in this volume:

- Person Demand Data – includes aviation, highways, transit and intercity bus, intercity rail, and rail transit.

- Freight Demand Data – includes discussions of truck, rail, waterborne and air cargo movements from the TRANSEARCH database; sources of Mexico/U.S. and Canada/U.S. freight traffic; non-manufactured freight traffic; and other enhancements to the basic TRANSEARCH database

- Intermodal Facilities – covers passenger data (i.e., airports, cruise terminals and intermodal transit stations) and freight data (i.e., airports, seaports, intermodal freight facilities, and tanker terminals)

- GIS and Transportation System Information – discusses the spatial coverages (i.e., modal networks, intermodal facilities, boundary layers), geometics (i.e, pipelines, freight rail, highways, and waterways), and safety and other GIS data

- Demand Models – documents the steps, methodologies, and data for the person mode shift model (calculates mode shifts for person movement) and the freight flow processor (calculates modes shifts and route changes for freight movement)

- Performance Measures – reviews the speed equation; the sources of user cost, fuel consumption, pollutant emissions and accident data; the multipliers that measure the impacts of expenditures on the economy; the five sets of performance measures for person movement; and freight performance measures

- Purchased Data – itemizes the sources of key purchased data sets.

In general, the chapters in this volume have been organized with the description of data sources first, followed by a discussion of processing steps and tools. Users of previous ITMS versions should note that the chapters have been reorganized to make information easier to find. Exhibits are referenced throughout the chapters, and most often are included at the end of the chapter because they are large. Exhibits typically include examples of data request letters as well as forms and look-up tables.

2. PERSON DEMAND

The ITMS includes transportation demand forecasts for ten, twenty, and thirty-year time horizons. Transportation demand forecasts are required for person movement, goods movement, and performance measures. The Booz·Allen team developed methodologies and proposed approaches to acquire transportation demand and performance forecasts and included the results in the ITMS planning tool. The methodologies have been developed based on field surveys, research, and limited data testing, all with advice and input from Caltrans staff and the ITMS Advisory Committee (i.e., District and Program coordinators).

The ITMS takes advantage of data from the latest year that information is most widely available. The update process was begun in 1998. 1996 was chosen as the base year with three forecast horizons at ten-year intervals (i.e., 2006, 2016, 2026).

General Approach

The general approach to collecting transportation forecasts required the use of:

- Secondary sources as much as possible -- the ITMS is not intended to produce custom data, but rather to leverage the extensive investment in transportation data by the public and private sector

- Renewable sources to facilitate future update -- the ITMS is a planning tool with an active database that will be updated and revised over time

- Centralized sources if available -- the study team developed a data collection hierarchy that focused team efforts on centralized data sources first, and unique individual data sources as a last resort, again to facilitate ease of update and consistency of forecasts.

This approach is consistent with the overall ITMS data collection philosophy.

Passenger Demand Forecast Sources

Transportation demand forecast models and tools are generally well established and routinely used for most transportation planning purposes. This is particularly true for ground transportation forecasts in urban areas, where Metropolitan Planning Organizations (MPOs) have a federal mandate to produce consolidated passenger and vehicle demand forecasts for the designated planning area. These forecasts cover all modes and primary transportation facilities in the region, regardless of ownership. When federal funds are involved, these are the forecasts that must be used in the planning process. In support of these requirements, the California ITMS used MPO demand forecasts in MPO regions.

In rural areas, the state department of transportation or regional transportation planning agency (RTPA) generally has responsibility for producing ground transportation forecasts. These are often based on less sophisticated techniques and approaches than are true with urban counterparts. When sanctioned forecasts were not available for ITMS corridor segments, the study team estimated future demand using growth rates by county of vehicle miles traveled as projected by the Caltrans state travel demand model.

Following the data collection hierarchy, the study team began with federal sources for passenger transportation forecasts. Our contact agencies included:

- The Federal Aviation Administration (FAA) provides the base data for all air passenger travel. Using the FAA ten percent ticket lift, we estimated passenger enplanements by airport pair. Next we summed up appropriate airport pairs to derive corridor volumes. We also used FAA ten-year passenger air travel and forecast data for estimating all base year and forecast passenger air travel. The 20 and 30 year forecast horizon projections will continue on the same rate of growth as the ten year forecast.

- The Federal Transit Administration (FTA) does not collect forecast information for transit. Instead, they record passenger demand and passenger miles by federally funded transit operators in the federally required Section 15 Report. However, these estimates are not at a corridor level of detail sufficient for use by the ITMS.

- The Federal Railway Administration (FRA) does not collect and maintain passenger volumes or forecasts by rail corridor. Amtrak, the primary California intercity rail provider, has both passenger estimates by corridor and periodic forecasts of future ridership.

- The Caltrans Districts and sixteen MPO provided their base and forecast data sets for the ITMS. Each MPO has a travel demand model for the base and forecast years. The travel demand estimates are updated routinely. The inventory of MPOs from which data was collected and the models used for travel forecasting are outlined below:

    - Association of Monterey Bay Area Governments -- MINUTP
    - Butte County Association of Governments -- MINUTP
    - Fresno Council of Governments -- MINUTP
    - Kern County Council of Governments – MINUTP
    - Merced County Association of Governments -- MINUTP
    - Metropolitan Transportation Commission -- MINUTP
    - Sacramento Area Council of Governments -- MINUTP
    - San Diego Association of Governments -- TRANPLAN
    - San Joaquin County Council of Governments -- MINUTP
    - San Luis Obispo Council of Governments -- MINUTP
    - Santa Barbara County Association of Governments -- System II
    - Shasta County RTPA -- MINUTP

— Southern California Association of Governments (SCAG) -- TRANPLAN
— Stanislaus Area Association of Governments -- MINUTP
— Tulare County Association of Governments -- MINUTP
— Yuma MPO (Arizona) -- TRANPLAN.

- California has 44 RTPAs that maintain passenger demand data. Some RTPAs have their own passenger demand model, but many rely on Caltrans or on manual or spreadsheet applications to forecast vehicle and passenger demand which could not be easily used by the ITMS. The MPOs noted above cover the same geographic region in urban areas as many of the RTPAs and their models were used for these areas, but in rural areas the ITMS used Caltrans' travel demand model data or district supplied information. The ITMS used the MPO forecast within an MPO region. For information only, a partial listing of RTPAs and the model used by that RTPA follow:

— Alpine County Transportation Commission -- no model
— Amador County Transportation Commission -- MINUTP
— Calaveras County Transportation Commission -- MINUTP
— Colusa County Transportation Commission -- no model
— Del Norte County Transportation Commission –no model
— El Dorado County Transportation Commission -- MINUTP
— Glenn County Transportation Commission -- no model
— Humboldt County Association of Governments -- no model
— Inyo County Transportation Commission – no model
— Kings County Regional Planning Agency -- MINUTP
— Lake County / City Area Planning Agency -- no model
— Lassen County Transportation Commission -- no model
— LA County Metropolitan Transportation Authority -- UTPS
— Madera County transportation Commission -- MINUTP
— Mariposa County Transportation Commission -- no model
— Mendocino Council of Governments -- no model
— Metropolitan Transit Development Board -- no model
— Modoc County Transportation Commission -- no model
— Mono County Transportation Commission -- no model
— Nevada County Local Transportation Commission -- MINUTP
— Orange County Transportation Authority -- TRANPLAN
— Placer County Transportation Commission -- MINUTP
— Plumas County Transportation Commission -- no model
— Riverside County Transportation Commission -- no model
— San Benito County Council of Governments -- no model
— San Bernardino County Assoc. of Governments – no model

— Sierra County Transportation Commission -- no model
— Siskiyou County Transportation Commission – no model
— Tahoe Regional Planning Agency -- TRANPLAN
— Tehama County Transportation Commission -- no model
— Trinity County Transportation Commission -- no model
— Tuolumne County Transportation Commission -- MINUTP
— Ventura County Transportation Commission -- no model.

- Individual passenger transportation operators (e.g., transit) and facilities (e.g., airports) were contacted to obtain passenger forecast data.

Performance Measure Forecast Data

Additional forecast data and calibration factors were required to calculate performance measures for forecast years. Mobile source emissions and economic forecast data are the two primary types of performance measure forecast data needed. Each of these two types is discussed below:

- EMFAC7 has been calibrated with base year and forecast year data by the California Air Resources Board. This database contains fleet mix and emissions by vehicle class and fuel type, and also has climatic data for California. The study team used this base year and forecast data to develop emissions factors for the ITMS.

- State economic forecast data was also required to develop economic impact factors for transportation investments. Such forecasts were obtained from the State of California, WEFA, and DRI at a statewide and county level.

Normalization and Problem Resolution

In collecting forecast data for the ITMS, the study team encountered some issues that required resolution. Initial fieldwork uncovered several common problems for which the study team developed resolution procedures. Common problems and their solutions included:

- Some base and forecast year data did not match ITMS requirements. Where this occurred, the study team used available information to determine annual growth rates between base and forecast years. These growth rates were then applied to available forecasts to arrive at the appropriate ITMS years.

- Some forecast years did not extend to a 30-year horizon. Initial data collection efforts identified few forecast sources that extended beyond ten years and even fewer to 30 years. The “growth rate” extrapolation/interpolation method described above was utilized to extend forecasts to the 30-year horizon using the last available annual growth rate to complete the forecast.

- Some agencies lacked an official forecast. While some transportation planning agencies have a formal process for developing and adopting a base and forecast scenario, others do not. The study team worked with the individual agencies to identify the most appropriate forecast for the ITMS (e.g., expected economic growth, funded improvements).

- No forecast was available for non-motorized transportation. In the initial field test, none of 40 agencies contacted could provide data for non-motorized transportation modes. Therefore, the ITMS does not include demand for non-motorized transport. Patrons arriving and departing intermodal facilities by mode (including non-motorized) is often available and is included for some passenger transportation facilities.

- Some future segments did not match current ITMS segments. This issue was resolved by using the weighted proportion of common segment demand per unit length for the future segment. The unit demand was then applied to an existing ITMS segment. This was performed manually from paper maps, within some demand models, and/or via ArcView's GIS functionality.

- No forecast was available for some agencies. The study team worked down the data collection hierarchy to find appropriate forecasts, but in some cases none existed. In such cases, the study team prepared a simple forecast of demand using base data and vehicle miles traveled growth rates by county provided in the Caltrans 1991 Travel Survey.

This chapter documents the development of person demand data for Version 3 of the Intermodal Transportation Management System (ITMS). The following modes are documented in this chapter:

Mode	Primary Data Source
Aviation	O&D Plus CD-ROM database distributed by Data Base

	Products, Inc.
Intercity Rail	California / Amtrak Intercity Rail Model (Caltrans Rail Program)
Highway / Urban Transit	Regional travel demand models from Metropolitan Planning Organizations

1. AVIATION

The ITMS Aviation Network includes the 14 airports in California. The routes connecting these airports are labeled as air corridors and contain attribute data summarizing level of activity.

1.1 Sources

The California air corridor look up table was developed using extracts from the O&D Plus CD-ROM database and FAA Terminal Area Forecasts:

- 1996 Origin-Destination Passenger Data (Part 121 and Part 135 Air Carriers) – This matrix shows inbound and outbound passenger counts from all 50 states to four largest California airports: Los Angeles, San Francisco, San Diego, and Sacramento.

- 1996 California Airport-Pair Data (Part 121 and Part 135 Air Carriers) – This matrix shows inbound and outbound passenger movements between the fourteen ITMS airports. In addition to passenger counts, this matrix also lists the distance between airport pairs, as well as the inbound and outbound fares.

- 1996 International Air Data (T-100) – showing enplanement data to and from Los Angeles and San Francisco International airports.

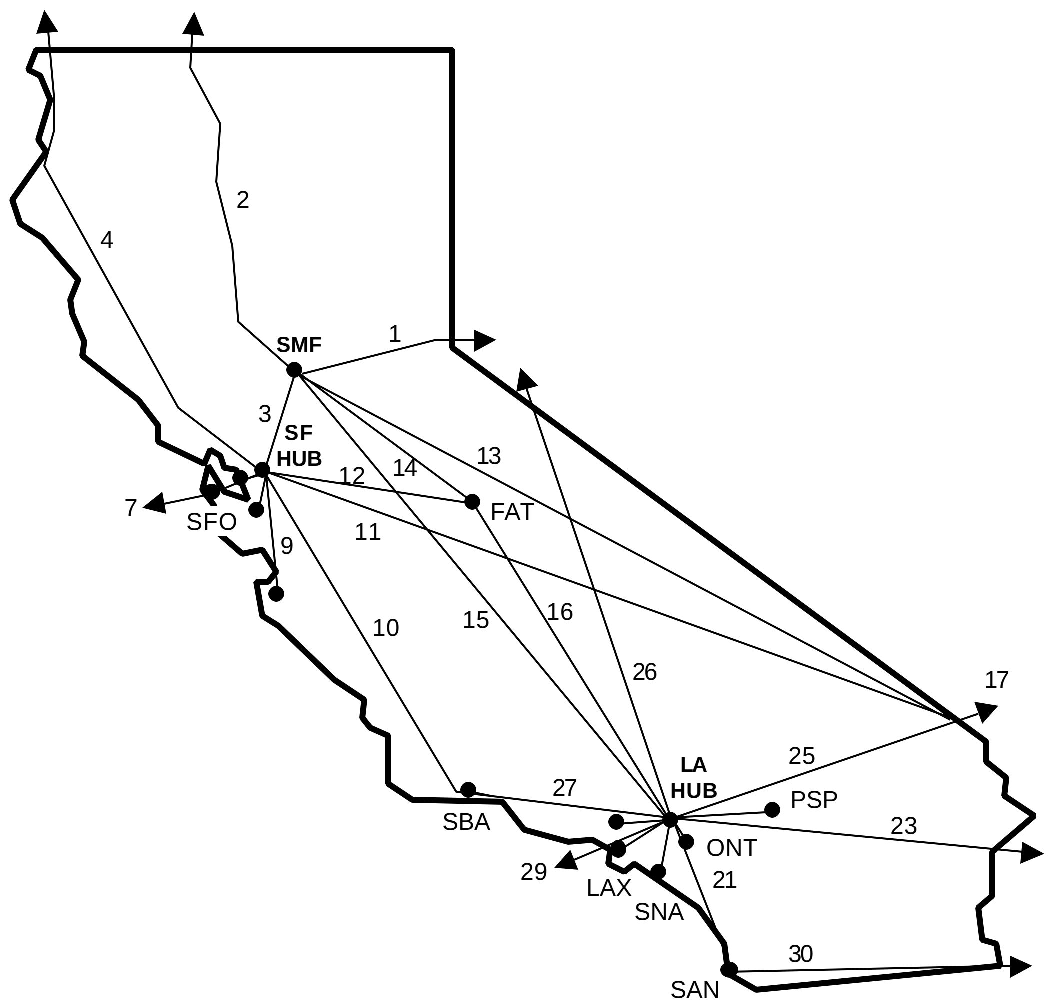
- FAA Terminal Area Forecasts – This data set includes passenger enplanements for the fourteen ITMS airports for 1996, as well as forecast volumes for 2000, 2005, and 2010.

1.2 Base Year Assignment

The ITMS air corridor contains 30 route segments. With 14 airports statewide and out-of-state destinations in each directions it would be infeasible to graphically represent all possible origin and destination pairs.

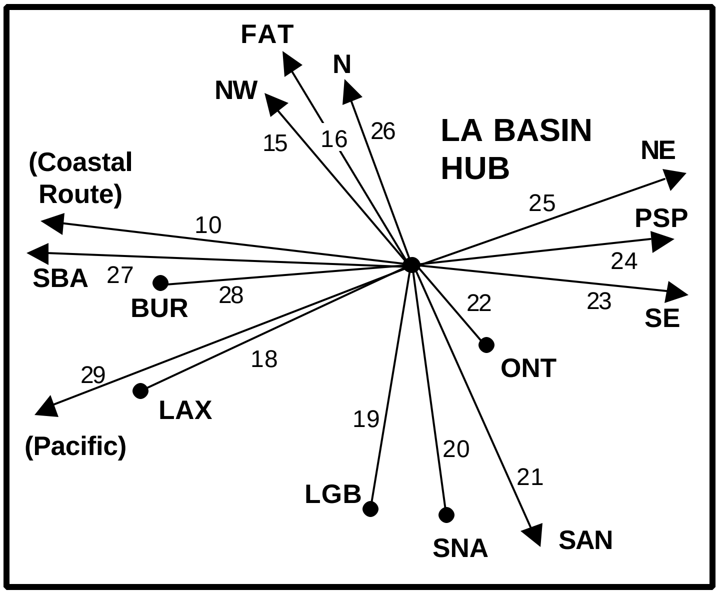
As such, a simple representation of the State aviation network was created that contains 30 segments. This is shown in Exhibit 2-1.

Exhibit 2-1
ITMS Aviation Network



The San Francisco and Los Angeles regions each contain a hub point representative of air traffic demand into those air basins, as shown below in Exhibit 2-2:

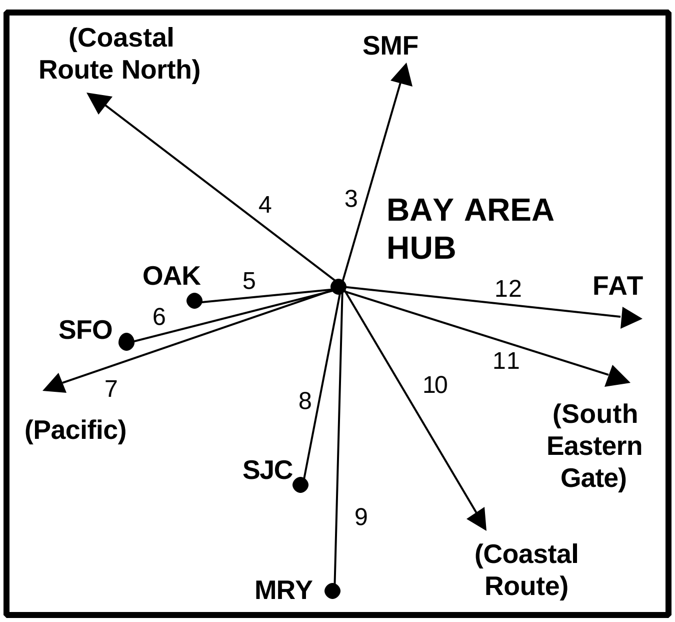
Los Angeles Hub



LEGEND

N	North
FAT	Fresno
NW	North-West
SBA	Santa Barbara
BUR	Burbank
LAX	Los Angeles
LGB	Long Beach
SNA	Orange County
ONT	Ontario
SE	South-East
PSP	Palm Springs
NE	North-East

San Francisco Bay Area Hub



LEGEND

SMF	Sacramento
OAK	Oakland
SFO	San Francisco
SJC	Jan Jose
MRY	Monterey
FAT	Fresno

The 1996 demand was assigned to the 30 segments with an intra-California assignment, a total for small California airports, the inter-state volumes, then finally the international volumes. Each segment demand was added and checked for each direction. The result from this task was a passenger volume on each 30 segment, each direction.

1.3 Developing Forecast Volumes Using FAA Terminal Area Forecasts

The FAA forecasts passenger enplanements on the national, regional, state, and airport levels. The FAA forecasts contain historic enplanement data for each of the 14 ITMS airports for 1996 and forecast data for 2000, 2005, 2010. Average annual growth percentage rates were developed for each ten year time period separating ITMS horizon years (e.g., 1996-2006, 2006-2016). Finally, we used linear extrapolations to develop forecast volumes for 2006, 2016, and 2026.

The last step in the process was to incorporate results into the air route coverage for the ITMS.

2. INTERCITY RAIL

California subsidizes three Amtrak provided passenger rail routes:

- **San Diegan** - From San Diego to San Luis Obispo
- **San Joaquin** - From Bakersfield to Sacramento
- **Capitol** - From Oakland to Sacramento.

The ITMS only contains data for these routes. There are several interstate passenger rail routes in California provided by Amtrak. These are not funded by the state, and therefore data on those routes was not available.

The Caltrans Rail Program has an intercity rail forecasting model. This model provides base year 1996 data as well as year 2020 forecast data. The data in the ITMS comes from this model. Exhibit 2-3 shows an example of the output from the model for the year 2006.

Exhibit 2-3
Sample Output, Amtrak/California Forecasting Model

ALIFORNIA 04 VISION 05/25/1999
EAR 2006 4:28 PM

ture Rail Trips by Link

Rail Stations		Feeder Bus		Capitol Rail		San Joaquin Rail				Feeder Bus	
Code	Name	On/Off	On Board	On/Off	On Board	On/Off	On Board	On/Off	On Board	On/Off	On Board
SJC	San Jose			154,542							
					154,542						
GAC	Santa Clara-Great America			310,517							
					464,733						
FMT	Fremont-Centerville			55,236							
					517,220						
HAY	Hayward			103,383							
					618,442						
OKJ	Oakland - JLS			226,095		46,155					
					822,315		46,155				
SFC	San Francisco - Ferry Bldg	604,854									
			604,854								
EMY	Emeryville			927,228		216,580					
					1,731,214						
BKY	Berkeley										

Subsequent to obtaining modal outputs for all horizon years, the rail attribute data was incorporated into the Amtrak intercity rail coverage and aggregated appropriately.

3. HIGHWAY/URBAN TRANSIT

Highway / transit travel demand data, both for 1996 and for the forecast years, was obtained primarily through the ITMS District coordinators, who themselves obtained the data through their counterparts at the regional MPO or RTPA.

It is important to note that both initial segmentation and route selection were determined by the ITMS coordinators themselves.

Exhibit 2-4 below lists the Caltrans District staff contact list at the time of data collection during most of 1999.

Exhibit 2-4
Travel Demand Model Data Contact List

District	Contact	Phone Number	Notes
1	Guy Luther or Martin Urkofsky	707/445-6407	
2	Marcia Sagami	530/225-3067	
3	John Linhart/Cynthia Smith	916/324-7877	
4	Julian Carroll	510/286-5598	Source: MTC Chuck Purvis 415/ 464-7731
5	Shayne Sandeman	805/549-3682	
6	Henry Oputa/Hector Rangel	209/488-4199	
7	Ed Humanic/ Dan Kopulsky/ Bill Mosby	213/ 897-1332 or -0804 or -4872	BAH supplied files
8	Richard Dennis	909/383-4825	BAH supplied files (SCAG only)
9	Ann Sutherland/ Tom Meyers	760/872-0658	
10	Jane Wegge	209/948-7112	
11	Sandy Johnson	619/688-3137	Source: SANDAG Bill MacFarlane 619/595-5305
12	Nam Vo	949/724-2229	BAH supplied files

Following are summaries of the status model development for each agency contacted and a description of the process the ITMS Development Team used to extract data from these models. MPOs are listed first, followed by RTPAs.

BUTTE COUNTY ASSOCIATION OF GOVERNMENTS - BCAG

The Butte County travel demand model is a daily traffic model that uses the MINUTP software program. The model years are 1995 and 2015. The model covers the entire county. It is exclusively a highway model; transit is not included. Loaded highway networks were provided for use in this study by District 3 staff.
No transit data is available since BCAG does not model transit in their county model.

Plots of the base year network were generated for the segmentation. Data was extracted using the NETVUE module of MINUTP to view and post link attributes of the loaded networks. Model data was compiled in a spreadsheet for ease of manipulating the data to arrive at the ITMS horizon year data. The following assumptions were made to convert the model data for the ITMS database:

- Because the model provides daily traffic volumes for the representative links, a 7.5 percent factor was applied to the daily volumes to get a peak hour volume.

- As a vehicle trip model, other sources needed to be used to estimate the average vehicle occupancy (AVO). An AVO of 1.42 was obtained from the Statewide Travel Survey for Butte County Freeway Use.

- Congested speeds were estimated by interpolating the congested speeds from model assignments.

File names

Bm95dly.net
BM15dly.net

ASSOCIATION OF MONTEREY BAY AREA GOVERNMENTS (AMBAG)

AMBAG utilizes MINUTP. The forecasted model data provided was prepared by District 5 staff. The model contains 1990 and 2015 as forecast years. District 5 staff provided analysis for this model.

FRESNO COUNCIL OF GOVERNMENTS (FRESNO COG)

The currently approved Fresno model is on a MINUTP platform and has three horizon years (1990, 2010 and 2020). The model assignments provided were a daily trip model without a mode choice component. The loaded highway networks were provided by District 6 staff. No transit files were provided.

To extract capacity, volume, and speed data, the following process was used:

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Peak hour volumes were estimated by applying a peak hour factor from the 1991 Caltrans Statewide Travel Survey: Final Report. This factor was 8.3% for Fresno County.

- Volumes and Congested speeds were interpolated from model assignment results.

- Peak hour passenger trip estimates for each segment were computed using vehicle occupancy factors applied to the hourly volumes. The vehicle occupancy factors were computed from the1991 Caltrans Statewide Travel Survey.

File names

Fx9022.dat, Pk1022.dat, Pk2022.dat

KERN COUNCIL OF GOVERNMENTS (KERN COG)

The currently approved Kern COG Model is on the MINUTP platform and has three horizon years (1999, 2010, and 2020). The model was provided as a daily trip model without a mode choice component. The model has five roadway classifications: freeway, highway, major arterial, minor arterial, and collector roads. The loaded highway networks were provided by District 6 staff. No transit files were provided.

To extract capacity, volume, and speed data the following process was used:

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Peak-hour volumes were estimated by applying peak hour factor from the 1991 Caltrans Statewide Travel Survey: Final Report. This factor was 8.9% for Kern County.

- Volumes and congested speeds for the ITMS horizon years were interpolated from the model assignments.

- Peak hour passenger trip estimates for each segment were computed using data from the 1991 Caltrans Statewide Travel Survey: Final Report.

Data Files

Ke99daly.dat, Ke10daly.dat, Ke20daly.dat

METROPOLITAN TRANSPORTATION COMMISSION (MTC)

The currently approved MTC model provided as a MINUTP assignment for both highway and transit. Two horizon years (1990 and 2020) were provided for use in the ITMS. The model has a mode choice component that allocates passenger trips between rail transit, ferry transit, bus transit, high occupancy auto vehicle (HOV 2 and HOV 3+), and lone occupancy auto vehicle modes. The model produces peak period auto vehicle estimates and transit trip estimates disaggregated by work and non-work purposes.

The model has four roadway classifications: freeway, expressway, major arterial, and collector roads as well as three ramp classifications: freeway to freeway ramps, metered ramps, and standard ramps. Each classification is segregated by area type. MTC is in the process of converting their UTPS-based model to a MINUTP platform.

The MTC provided highway networks in MINUTP format, and transit output files for each of the horizon years. The highway assignments were provided as AM peak period assignments. Transit assignments were provided as work and non-work assignments in production / attraction format.

ITMS Conversion Process

Highway Data

The MTC provided 1990 pre-assigned and 2020 assigned networks via diskette. To extract capacity, volume, and speed data, the following process was used:

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Peak hour travel model volumes determined by taking a proportion of the two hour assignment period according from percentages in the Statewide Travel Survey. Daily volumes were calculated by dividing by the percentage of daily traffic occurring in those peak hours (adjusting the volumes to daily conditions).

- Congested speeds were interpolated based on model assignment results. Because the assignment was provided as an AM assignment only, the lowest speed in either direction was applied to both directions.

- Peak hour passenger trip estimates for each segment were computed using vehicle occupancy factors applied to the hourly volumes. The vehicle occupancy factors were obtained from the Caltrans Statewide Travel Survey.

Highway Data Files
1990los.dat, d202net.dat

Bus Transit Data

- Bus routes operating on ITMS segments were identified using route schedules available from operators.

- The aggregate number of buses per hour and per day was summed according to the number of buses for each individual bus route operating on an ITMS segment.

  Ridership totals were determined by summing all transit assignments together at the maximum load point ridership for each line. Then a percentage of each that occur in peak hour peak direction was applied.

  Speeds on the roadway network were determined to be the higher of the speeds in parallel mixed-flow or HOV segments (if HOV was available).

Bus Transit Data Files

1990: lall004.prn, lall005.prn, lall006.prn
2020: lall006.prn, lall007.prn, lall008.prn

Rail Transit Data

- Lines operating within an ITMS corridor were identified.

- Posted schedules were used to determine the frequency of daily and peak hour trains.

- Volumes were determined on a link-by-link basis for all rail operators for each volumes file and added together. The results were added for both direction to derive daily volumes, and a percentage from the Statewide Travel Survey was applied for the peak hour peak direction volumes.

Rail Transit Data Files

1990: lall004.prn, lall005.prn, lall006.prn
2020: lall006.prn, lall007.prn, lall008.prn

MERCED COUNTY ASSOCIATION OF GOVERNMENTS - MCAG

The MCAG model is a daily vehicle model that uses the MINUTP software package. The model covers the entire county and portions of the adjacent counties. The model base year is 1990 and the forecast year is 2020. Transit service is limited to Dial-A-Ride service and is not significant enough to include in the demand model. District

10 staff provided loaded networks for this study. No transit data was received from MCAG since transit is not included as part of their model.

Representative links were identified using the plots and NETVUE. Base and future year link data was extracted from the network using NETVUE. Data for the ITMS horizon years were interpolated using the following assumptions:

- The peak hour volume was assumed to be 8.9 percent of the daily volume.

- A region-wide AVO of 1.31 from the Statewide Travel Survey for Merced County was used.

- Congested speeds were estimated by interpolating the congested speeds from model assignments.

File names

Mcag90.dat
Mcag20.dat

SACRAMENTO AREA COUNCIL OF GOVERNMENTS (SACOG) -- PRIMARY MODEL

The currently approved SACOG model is on the MINUTP platform. Two horizon years (1994 and 2020) were provided for use in the ITMS. The model has a mode choice component that allocates passenger trips between rail transit, bus transit, high occupancy auto vehicle (HOV 2 and HOV 3+), and lone occupancy auto vehicle modes. The model produces peak hour auto vehicle estimates and transit trip estimates disaggregated by work and non-work purposes. The model has six roadway classifications: freeway, expressway, major arterial, minor arterial, and collector roads. The transit data is provided in production / attraction format for daily trips. The agency also maintains a separate model for Yuba County and Sutter County. The Yuba / Sutter model is described in its own section. Data files were provided by District 3 staff for both transit and highway assignments.

ITMS Conversion Process

Highway Data

To extract capacity, volume, and speed data, the following process was used:

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Peak hour travel volumes were provided directly from model assignments. Daily travel volumes were determined by summing travel assignments from each of the time periods available in the SACOG model.

- Congested speeds were interpolated according to the congested speed results from model assignments..

- Peak hour passenger trip estimates for each segment were computed using vehicle occupancy factors applied to the hourly volumes. The vehicle occupancy factors came from the Statewide Travel Survey.

Highway Data Files

Ob94ph.dat, Ob94dly.dat, Nb20ph.dat, Nb20dly.dat

Rail Transit Data

- Using the MINUTP NETVUE graphics interface, work and non-work rail transit volumes were recorded from the screen display.

- Data from each direction was summed and divided by two to define daily travel. Peak hour demand was derived by using factors from the Statewide Travel Survey.

- Operating speeds were defined according to speeds provided by the model networks.

Bus Transit Data

- Using the MINUTP NETVUE graphics interface, work and non-work rail transit volumes were recorded from the screen display.

- Data from each direction was summed and divided by two to define daily travel. Peak hour demand was derived by using factors from the Statewide Travel Survey.

- Travel speeds utilized the higher of mixed-flow or HOV (where available) from the highway assignments.

Transit Data Files

Dg94155.prn, Dg94156.prn, Dg20061.prn, Dg20062.prn

SACRAMENTO AREA COUNCIL OF GOVERNMENTS (SACOG) -- YUBA COUNTY/SUTTER COUNTY SUB-AREA MODEL

The currently approved SACOG, Yuba / Sutter model is on the MINUTP platform. Two horizon years (1992 and 2020) were provided for the ITMS. The model has both peak hour and daily trip assignments available. The model has five roadway classifications (freeway, expressway, major arterial, minor arterial, and collector roads), segregated by area type. Data files were provided by District 3 staff.

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Congested speeds for peak hours were interpolated based on model assignments.

- Peak hour passenger trip estimates for each segment were computed using vehicle occupancy factors applied to the hourly volumes. The vehicle occupancy factors were computed from trip tables provided by Statewide Travel Survey.

Data File Names

Ys92peak.dat, Ys92dly.dat, Ys20ph.dat, Ys20dly.dat

SAN JOAQUIN COUNTY COUNCIL OF GOVERNMENTS (SAN JOAQUIN COG)

The model provided for use for the ITMS is on the COMSIS MINUTP platform and has two horizon years (1996 and 2016). The model results provided were from their daily trip model. The model has five roadway classifications: freeway, highway, major arterial, minor arterial, and collector roads segregated by area type. District 10 staff provided highway networks from the San Joaquin COG model for use in this study.

To extract capacity, volume, and speed data, the following process was used:

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Peak-hour volumes were estimated by applying a peak hour factor from the 1991 Caltrans Statewide Travel Survey . This factor was 8.5% for the San Joaquin region.

- Congested speeds for each horizon year was interpolated from congested speed results found in the loaded networks.

- Peak hour passenger trip estimates for each segment were computed using vehicle-occupancy factors applied to the hourly volumes. The vehicle-occupancy factors were taken from the Caltrans *Statewide Travel Survey: Final Report.*

Data File Names

Rp1996.dat, Rp2016.dat

SAN LUIS OBISPO COUNCIL OF GOVERNMENTS (SLOCOG)

SJCOG utilizes MINUTP. The forecasted model data provided was prepared by District 5 staff. The model contains 1996 and 2016 as forecast years. District 5 staff provided analysis for this model.

SHASTA COUNTY REGIONAL TRANSPORTATION PLANNING AGENCY (SHASTA COUNTY RPTA)

Status of Model Development

The currently approved Shasta County model is on the COMSIS MINUTP platform and has two horizon years (1996 and 2020). The model is a daily trip model without a mode choice component. The model has five roadway classifications: freeway, highway, major arterial, minor arterial, and collector roads. The Shasta County RPTA is currently updating their model. The model is maintained by the City of Redding and is based on a nine-month year. DKS staff provided model assignment results for this study.

To extract capacity, volume, and speed data, the following process was used:

- Node numbers defining the end points of ITMS segments were identified using the MINUTP NETVUE graphics interface and recorded.

- Peak-hour volumes were originally estimated by applying peak hour factor from the 1991 Caltrans *Statewide Travel Survey: Final Report.* This factor was 8.4% for Shasta County.

- Congested speeds were interpolated from the model runs provided.

- Peak hour passenger trip estimates for each segment were computed using vehicle-occupancy factors applied to the hourly volumes. The vehicle-occupancy factors were obtained from the Caltrans *Statewide Travel Survey: Final Report*.

SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS/IMPERIAL COUNTY TRANSPORTATION COMMISSION

The Imperial County model is a TRANPLAN-based daily and peak hour vehicle trip model. The base year is 1995, and 2015 is the forecast year. The loaded highway networks were provided by District 11 staff for use in this study in ArcView GIS. Transit data was not available for this model.

The base-year plots were generated in-house for the model segmentation. Representative links were identified using the plots and ArcView. Base and future year link data were extracted from the network using ArcView. Data for the ITMS horizon years were interpolated using the following assumptions:

- Since the model is a vehicle-trip model, the region-wide AVO from the 1991 Statewide Travel Survey was used.

- Congested speeds were estimated by interpolating the congested speeds from model assignments.

- Peak-hour speeds were calculated using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

File names

Impv95.shp, Imp20.shp

TUOLUMNE COUNTY AND CITIES AREA PLANNING COUNCIL (TCCAPC)

The Tuolumne County model is a MINUTP-based daily vehicle trip model. The base year is 1993 and 2020 is the forecast year. The loaded highway networks were provided by District 10 staff for use in this study. A review of available models indicated that the two networks were inconsistent and apparently resulted from separate model development efforts. Transit data was not available for Tuolumne since transit trips are not modeled.

The base-year plots were generated in-house for the model segmentation. Representative links were identified using the plots and NETVUE. Base and future year link data were extracted from the network using NETVUE. Data for the ITMS horizon years were interpolated using the following assumptions:

- The peak hour was assumed to be 8.3 percent of the daily traffic volumes.

- Since the model is a vehicle-trip model, the rural AVO of 1.32 from the 1991 Statewide Travel Survey was used.

- Peak-hour speeds were calculated using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

Where inconsistencies were found between the 1993 and 2020 models, the data from the 1993 model was used, as it was found to be most appropriate.

File names

Tuol93C.dat, Tuol15.dat

STANISLAUS AREA ASSOCIATION OF GOVERNMENTS - SAAG

The SAAG model is a MINUTP-based person trip model. The model base year is 1990. Forecasts are available for 2025. The model covers the entire county. Person trips are generated for five trip purposes - home-work, other-other, work-other, home-work, and home-shop. While the agency does not employ a formal mode choice model, the SAAG model includes a factoring process that accounts for transit. The transit network is not formally defined as part of the county model. Trips are assigned to the highway network using a five-iteration equilibrium assignment. District 10 staff provided the highway network. Since a transit network was not coded in the model, transit data was not obtained from SAAG.

Base and future year link data was extracted from the network using NETVUE. The model link data was compiled in a spreadsheet. The following assumptions were made to convert the data for the ITMS database:

- The peak hour was assumed to be 8.1 percent of the daily traffic volumes.

- Since the model starts by generating person trips, the region-wide AVO was estimated using data from the Statewide Travel Survey results for Stanislaus County.

- Congested speeds were estimated by interpolating the congested speeds from model assignments.

File names

Saag1990.dat,Saag2025.dat

SAN DIEGO ASSOCIATION OF GOVERNMENTS - SANDAG

The SANDAG travel demand model uses the UNIX version of the TRANPLAN software. The graphical image is maintained in a geographic information system (GIS). Link data is imported to the GIS. Peak and off-peak models are maintained for 1990 and 2015. The peak-period model covers the peak six hours of the day from 6:00 to 9:00 am and from 3:00 to 6:00 pm. The remaining hours of the day are covered by the off-peak model. Transit networks are coded as part of the model. Both light rail and buses are included in the 1990 base year network. The 2015 future network assumes commuter rail service in addition to an expanded light rail service and bus service.

Traffic assignments were provided by SANDAG in ArcView GIS format for the horizon years of 1996, 2006, and 2016. Adjustments for 2026 were based on applying the 10-year growth increment from the 2006 to 2016 decade to 2026.

- AM peak hour volumes were provided directly. The assumption was made that the higher peak hour volume should apply to both directions.

- The one-way peak period traffic was assumed to be 15.0% of the daily peak hour summed in both directions (or an effective two hour peak period). This was derived using the Statewide Travel Survey time-of-day information for these two time periods compared to the entire day.

- A region-wide AVO of 1.37 and 1.35 were assumed. This is based on the Statewide Travel Survey.

- Congested speeds were provided by SCAG for 1996, 2006, and 2026. The 2026 speeds were interpolated for the prior decade. The lower speed from each direction on the link was assumed to be the most congested speed.

Transit ITMS Conversion Process and Assumptions

For the base year transit data, SANDAG staff provided ridership information and routes for 1996, 2006, and 2016. Service data, such as headways, were taken from the posted transit schedules. AM peak period headways were assumed for both directions. This provided 6-hour peak period, off-peak, and daily transit loadings by route.

The operator, mode, number of bus lines, directional headways, directional speeds, directional capacity, and directional passenger loadings were compiled into a spreadsheet by segment as identified for the highway network. The rail and bus operations were entered separately. The following assumptions were made regarding this data:

- The average headway for the segment included all buses running on that segment.

- The speeds for buses were taken directly from the highway network data. Speeds for the light rail and commuter rail service were derived from the reports based on the distance and travel time.

- An even distribution of trips in either direction was assumed.

- For peak hour directional passenger volumes, a factor of 0.26 was applied to the 6-hour peak loading for the peak direction. The peak hour peak direction was assumed to be away from the city center. For the non-peak direction, a factor of 0.055 was applied to the 6-hour peak loading.

Data was provided for 1996, 2006, and 2016. The growth to 2026 was derived based on the daily passenger volume changes between 2006 to 2016 being applied to the 2016 volumes.

File names

Hwy1996.shp, Hwy2006.shp, Hwy2016.shp, Tritms.shp (1996, 2006, 2016)

SANTA BARBARA COUNTY ASSOCIATION OF GOVERNMENTS - SBCAG

The SBCAG model is a System II model that covers Santa Barbara County. The base year is 1996, and the forecast year is 2015. The model predicts daily traffic volumes. Data from SBCAG was supplied and adjusted by District 5 staff. Final spreadsheets were submitted. Since District 5 prepared the files, no ITMS Conversion Process was required.

File names

Not available

SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS - SCAG

SCAG runs its travel demand model using TRANPLAN software. The base year is 1994. Forecast is made for 2020. The day is divided into four time periods that are forecast separately. The AM peak period covers the morning peak period from 6:00 to 9:00 am. The PM peak period covers a four-hour period from 3:00 to 7:00 pm. The midday and the night-time periods complete the day. Both transit and highway forecasts for 1994 and 2020 were provided by SCAG as ArcView shape files.

Once the links were identified for the base-year network, the link data was extracted from a ASCII file of the entire loaded The 1994 and 2020 peak period link data was entered into a spreadsheet file where the ITMS horizon years were interpolated using the following assumptions:

- To arrive at peak hour volumes, the higher of 0.25 of the PM peak period traffic or 0.33 of the AM peak period traffic was used.

- A region-wide AVO of 1.30 for peak hour travel and 1.31 for daily travel were derived using data form the Statewide Travel Survey.

- The congested speeds were interpolated for the ITMS years based on the congested speeds provided from the 1994 and 2020 assignments.

Transit ITMS Conversion Process and Assumptions

For the base year transit data, an Los Angeles Metropolitan Transportation Authority (MTA) Bus System map and an Orange County Transit District map were used to identify bus lines that traveled segments of the ITMS highway network.

Headways were taken from the timetables posted by SCAG. The daily and peak loadings by line segment were provided in production/attraction form. All trips in each direction was added together and divided by two for daily travel, and peak hour travel was assigned according to data on the percent of transit peak hour travel from the Statewide Travel Survey. The speeds for buses were taken directly from the highway network data. Speeds for the light rail and commuter rail service were derived from service plans.

The 1994 and 2020 transit data was interpolated for the ITMS horizon years assuming that the transit service did not change from the 1994 service. If the transit line exists in both 1994 and 2020, a growth factor was derived and applied to estimate loadings for the different horizon years. For transit lines not in the 1994 network, growth was allocated based on other representative rail segments.

File name

Scag1994.shp, Scag2020h.shp, Scag94tr.shp, Scag20tr.shp

STANISLAUS AREA ASSOCIATION OF GOVERNMENTS - SAAG

The SAAG model is a MINUTP-based person trip model. The model base year is 1990. Forecasts are available for 2025. The model covers the entire county. Person trips are generated for five trip purposes - home-work, other-other, work-other, home-work, and home-shop. While the agency does not employ a formal mode choice model, the SAAG model includes a factoring process that accounts for transit. The transit network is not formally defined as part of the county model. Trips are assigned to the highway network using a five-iteration equilibrium assignment. District 10 staff provided the highway network. Since a transit network was not coded in the model, transit data was not obtained from SAAG.

Base and future year link data was extracted from the network using NETVUE. The model link data was compiled in a spreadsheet. The following assumptions were made to convert the data for the ITMS database:

- The peak hour was assumed to be 8.1 percent of the daily traffic volumes.

- Since the model starts by generating person trips, the region-wide AVO was estimated using data from the Statewide Travel Survey results for Stanislaus County.

- Congested speeds were estimated by interpolating the congested speeds from model assignments.

File names

Saag1990.dat,Saag2025.dat

TULARE COUNTY ASSOCIATION OF GOVERNMENTS - TCAG

The TCAG model is a daily vehicle model. The model covers the western portion of the county up to the National Forests and Parkland. Years 1998, 2006, and 2018 are modeled. A total of seven trip purposes are assigned using a two-iteration, stochastic assignment. Transit levels in Tulare County at this time do not dictate the need to include transit in the county model. Networks from a Tulare County assignment were provided by District 6 staff .

The base-year plots were generated in-house and used to segment the network and identify representative links with the aid of NETVUE, the MINUTP utility that allows the user to view the loaded network. Link data was extracted from the loaded networks using NETVUE. The data was compiled in a spreadsheet, and data for the ITMS horizon years were interpolated using the following assumptions:

- The peak hour was assumed to be eight percent of the daily traffic volumes.
- The region-wide AVO of 1.32 was taken from the 1991 Statewide Travel Survey.
- The congested speeds were interpolated for the ITMS years based on the congested speeds provided from the assignments.

File name

Aq9822.dat, Aq0622.dat, Aq1822.dat

CALAVARAS COUNTY COUNCIL OF GOVERNMENTS (CCCOG)

The Calavaras County model is a MINUTP-based daily vehicle trip model. The base year is 1995 and 2015 is forecast. The loaded highway networks were provided by District 10 staff for use in this study. Transit data was not available for Calavaras since transit trips are not modeled.

The base-year plots were generated in-house for the model segmentation. Representative links were identified using the plots and NETVUE. Base and future year link data were extracted from the network using NETVUE. Data for the ITMS horizon years were interpolated using the following assumptions:

- The peak hour was assumed to be 8.3 percent of the daily traffic volumes.

- Since the model is a vehicle-trip model, the rural AVO of 1.32 from the 1991 Statewide Travel Survey was used.

- Peak-hour speeds were calculated using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

File names

Cala95.dat, Cala20.dat

MARIPOSA COUNTY TRANSPORTATION COMMISSION (MCTC)

The Mariposa County model is a MINUTP-based daily vehicle trip model. The base year is 1994 and horizon year is 2016. The loaded highway networks were provided by District 10 staff for use in this study. Transit data was not available for Mariposa since transit trips are not modeled.

The base-year plots were generated in-house for the model segmentation. Representative links were identified using the plots and NETVUE. Base and future year link data were extracted from the network using NETVUE. The ITMS horizon years were interpolated using the following assumptions:

- The peak hour was assumed to be 8.3 percent of the daily traffic volumes.

- Since the model is a vehicle trip model, the rural AVO of 1.32 from the 1991 Statewide Travel Survey was used.

- Peak hour speeds were calculated using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

File names

Mari96.dat, Mari16.dat

KINGS COUNTY ASSOCIATION OF GOVERNMENTS (KCAG)

The Kings County model is a MINUTP-based daily vehicle trip model. The base year is 1995 and horizon year is 2020. The loaded highway networks were provided by District 6 staff for use in this study. Transit data was not available for Kings County since transit trips are not modeled.

The base-year plots were generated in-house for the model segmentation. Representative links were identified using the plots and NETVUE. Base and future year link data were extracted from the network using NETVUE. The ITMS horizon years were interpolated using the following assumptions:

- The peak hour was assumed to be eight percent of the daily traffic volumes.
- Since the model is a vehicle-trip model, the rural AVO of 1.32 from the 1991 Statewide Travel Survey was used.
- Peak-hour speeds were calculated using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

File names

Mari96.dat, Mari16.dat

ALPINE (DISTRICT 10) RURAL

District 2 maintains a spreadsheet-based forecasting system for links not included in the SCAG model. The list contains traffic volume estimates for peak hour and daily vehicles, as well as growth rates based on trends. No data was provided by District 10. Model inputs were developed from information available from Caltrans traffic count records for daily- and peak-hour volumes. Directionality was assumed to be 50 percent of traffic. Traffic count growth rates were calculated at a one percent annual growth rates.

The following methods were used to complete the ITMS fields:

- Directionality was assumed to be 50 percent of traffic.
- Traffic count forecasts were calculated at a 1% annual growth.
- Peak hour speeds were calculated using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

AMADOR COUNTY TRANSPORTATION COMMISSION (AMADOR COUNTY TC)

The currently approved Amador County TC model is on the MINUTP platform and has two horizon years (1990 and 2014). It is a daily model. There is no transit assignment component to this model. District 10 staff provided network assignments for this model.

Data File Names

Am14.dat, Am20.dat

SISKIYOU, MODOC, TRINITY, LASSEN, TEHEMA AND PLUMAS (DISTRICT 2) RURAL

District 2 maintains a database in FileMaker Pro-based forecasting system. District Staff provided information for links not included in the Shasta County model. The list contains traffic volume estimates for peak hour and daily vehicles, as well as growth rates based on trends. District 2 staff provided roadway capacities, free-flow speeds, and traffic volume forecasts for these roadways.

Additional data was developed for peak hour speeds using the Bureau of Public roads methodology. An exponent of 4 was used in the speed-delay curves.

MADERA COUNTY TRANSPORTATION COMMISSION - MCTC

The Madera County model is a MINUTP-based daily vehicle trip model. The base year is 1996, and two years - 2010 and 2020 - are forecast. The model coverage includes Madera County, Fresno County, and Merced County.

The loaded highway networks were provided by District 6 staff for use in this study. Transit data was not available for Madera since transit trips are not modeled.

The base year plots were generated in-house for the model segmentation. Representative links were identified using the plots and NETVUE. Base and future year link data were extracted from the network using NETVUE. Data for the ITMS horizon years were interpolated using the following assumptions:

- The peak hour was assumed to be eight percent of the daily traffic volumes.

- Since the model is a vehicle trip model, the region-wide AVO from the 1991 Statewide Travel Survey was used.

- Congested speeds were estimated by interpolating the congested speeds from model assignments.

File names

Md9623.dat, Md1023.dat, Md2023.dat

SAN BERNARDINO AND RIVERSIDE (DISTRICT 8) RURAL

District 8 maintains a spreadsheet-based forecasting system for links not included in the SCAG model. The list contains traffic volume estimates for peak-hour and daily vehicles, as well as growth rates based on trends.

District 8 staff provided roadway capacities, free-flow speeds, and traffic volume forecasts for these roadways.

Additional data was developed for peak hour speeds using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

INYO AND MONO COUNTY (DISTRICT 9) RURAL

District 9 maintains a spreadsheet-based forecasting system for links not included in Mono or Inyo Counties. The list contains traffic volume estimates for peak-hour and daily vehicles, as well as growth rates based on a percentage growth rate that varies by facility. District 9 staff provided roadway capacities, free flow speeds and traffic volume forecasts for these roadways.

Additional data was developed for peak hour speeds using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

DEL NORTE, HUMBOLDT, MENDOCINO AND LAKE COUNTIES (DISTRICT 1) RURAL

District 1 maintains a spreadsheet-based forecasting system. The list contains traffic volume estimates for peak-hour and daily vehicles, as well as growth rates based on trends. Data for District 1 facilities was developed based on traffic count data from Caltrans, and annual growth rates used to develop for 1998 and 2003 forecasts.

An annual growth rate calculation was made using forecast changes as a growth in actual vehicles for each year. This annual growth rate was applied to 20 and 30 year forecasts to define the future year volumes. Additional data was developed for peak hour speeds using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

COLUSA, GLENN, NEVADA, SIERRA, EL DORADO, (DISTRICT 3) RURAL

District 3 maintains a spreadsheet-based forecasting system for links not included in the SCAG model. The list contains traffic volume estimates for peak-hour and daily vehicles in 1998 conditions, as well as twenty year (2018) forecasts. District 3 staff provided roadway facility types and number of lanes, traffic volume estimates (including peak-hour and peak-direction factors), and forecasts for these roadways.

Future horizon year data was determined by applying the annual growth determined from the twenty-year forecasts to each ITMS horizon year. Additional data was developed for peak hour speeds using the Bureau of Public roads methodology. An exponent of four was used in the speed-delay curves.

3. FREIGHT DEMAND DATA

Over one billion tons of freight moves annually in the state of California. Understanding the commodity composition, origins, and terminations, the forms of transportation employed, and projected trends associated with these patterns is an essential prerequisite for effective transportation planning, but this information is fragmentary. In general, the pieces that do exist lack uniformity with each other in terms of consistent descriptions, measures, and coverage. As a result, freight planning has often been conducted separately from other highway planning or worse, ignored all together. One of the major advantages of the Intermodal Transportation Management System (ITMS) is that it brings together the pieces of information concerning California's freight transportation traffic flows, fills in hole in the data, and put the results into a consistent and uniform database.

Confidentiality in the collection and display of freight traffic information limits the information that is available. Government organizations that collect traffic data are sensitive about its proprietary nature. For this reason, the Transportation Safety Board (TSB), the Corps of Engineers (COE), and the Bureau of the Census are cautious about displaying segments of the transportation markets in ways that may reveal proprietary information about private businesses. At the same time, there are organizations collecting pieces of information that contain aspects of the physical business network and trying to put these pieces together for planning and strategy purposes. Ultimately, those who have a need for freight traffic flow data must be willing to juggle occasionally the requirements of their own planning needs with the reluctance to provide information about the sensitive or proprietary activities of their companies.

Very few public sources of freight traffic-flow information draw from all traffic movements. Most are based on samples. These samples have their greatest reliability where they are used to describe markets at the level of their original intended use. Typically, however, analysts, planners, and managers are so interested in adding detail to the original sample, that they are willing to compromise precision to gain a more detailed view of traffic patterns.

The ITMS relies on three primary sources for the freight traffic database:

- TRANSEARCH / Intermodal Freight Visual Database - This commercially available, proprietary source of domestic freight traffic flow information covers rail carload, intermodal, for-hire truckload, less-than-truckload, private truck, air, and water and forms the base of the ITMS freight data for 1996.

- TRANSEARCH International and Port Import Export Reporting Service (PIERS) – the domestic database was supplemented with information from the TRANSEARCH International database on movements between California and Canada and Mexico. PIERS provided the key to identifying the inland origins and destinations that correspond to the domestic portion of the imports and exports.

- DRI / McGraw Hill – A forecast of the U.S. economy formed the basis for predicting freight movements in future years (i.e., 2006, 2016, and 2026).

Additional research was necessary to provide information on "non-manufactured" freight. This traffic is generally related to motor carrier transportation, which is not collected in a systematic or centralized manner. Adjustments were also made to take into account empty trailer movements. Secondary traffic, or the shipments by truck that originate in warehouses or distribution centers, are now included as a standard feature of the TRANSEARCH / Intermodal Freight Visual Database.

The freight database developed for ITMS is presented at a county-to-county level and on a six-digit North American Industry Classification System (NAICS) level, although less detail is available for some commodities. Consequently some of the data is presented at five, four, or three digits. To produce information at this level of detail required the use of a series of data sources to disaggregate from state or broader market levels to county and even to zip code levels. Such a process involves the use of population data by county and plant and worker location by county as well as the Bureau of Economic Analysis Input / Output (I / O) Table of the U.S. economy. Of equal significance is the fact that the process must rely on a variety of assumptions about potential distribution patterns implicit in the use of this non-traffic data. When producing information at this level of detail it is important to raise the caution as to the absolute reliability of each data component. Overall, however, the database provides a reasonable picture of transportation flows in California.

The ITMS freight database includes information on freight movements for a variety of modes (e.g., truck, rail, intermodal, airborne, and waterborne) for four years. The base year for the database is 1996. Future year forecasts are provided for 2006, 2016, and 2026. A separate file exists for each forecast year.

The last section of this chapter provides a data dictionary for the ITMS freight database and describes the contents of the database. The other sections provide detailed information on each of the components of the ITMS freight flow database. The account includes the sources that are used and generally how they were put together.

The remainder of this chapter contains the following nine sections:

- TRANSEARCH – describes the propriety, commercially available database provided by Reebie Associates

- Mexico / U.S. Freight Movement Data – describes how Mexican import / export data was added to the domestic database

- Canada / U.S. Freight Movement Data – describes how Canadian import / export data was added to the domestic database

- Non-Manufactured Freight Traffic Activity – describes the sources for and basic approach to adding freight traffic for non-manufactured goods

- Secondary Shipments – describes the addition of short-haul, distribution-related truck movements

- Empty Trailer Movements – describes how the database accounts for empty truck movements

- Forecasts – describes the process for forecasting freight movements in 2006, 2016, and 2026

- Database Additions – describes how trailer equivalents are calculated, the addition of import-export flags, and the assignment of freight traffic to specific routes.

- ITMS Database – provides a data dictionary and describes the contents of the ITMS Freight Database

1. TRANSEARCH

Reebie Associates reconstructed the proprietary, commercially-available TRANSEARCH database from the most recent set of publicly available freight traffic flow information. The result is a database of origin-to-destination flows by six-digit NAICS commodities for seven modes of transportation: for-hire truckload, less-than-truckload, private truckload, conventional rail, rail/truck intermodal, air, and water. The ITMS is built upon the basic TRANSEARCH, which Reebie has made available to Caltrans, and includes many enhancements that make the data more useful for California freight planning. These enhancements are described in later sections of this chapter.

Exhibit 3-1 shows the basic data sources for TRANSEARCH. These data sources are not uniform in terms of the geographic areas used, commodity definitions, units of measure, and the base years presented. The task is to draw these disparate sources together, checking their completeness and basic validity, assigning commodity, geography and mode descriptions and then putting them into a common format. The biggest challenge is in the development of truck flow information.

Exhibit 3-1
Principal TRANSEARCH Sources

PRIMARY DOMESTIC TRAFFIC FLOW SOURCES

- Annual Motor Carrier Data Exchange (Proprietary Shipment Data)
- Annual STB Railroad Waybill Sample
- Annual Corps of Engineers Waterborne Commerce Statistics
- Annual Federal Aviation Administration Airport Activity Statistics
- Import/Export Trade Statistics
- Annual Department of Energy Coal Movement Statistics
- Annual Department of Agriculture Produce Movement Data
- Census of Transportation - Commodity Flow Survey

PRIMARY PRODUCTION AND SHIPMENTS SOURCES

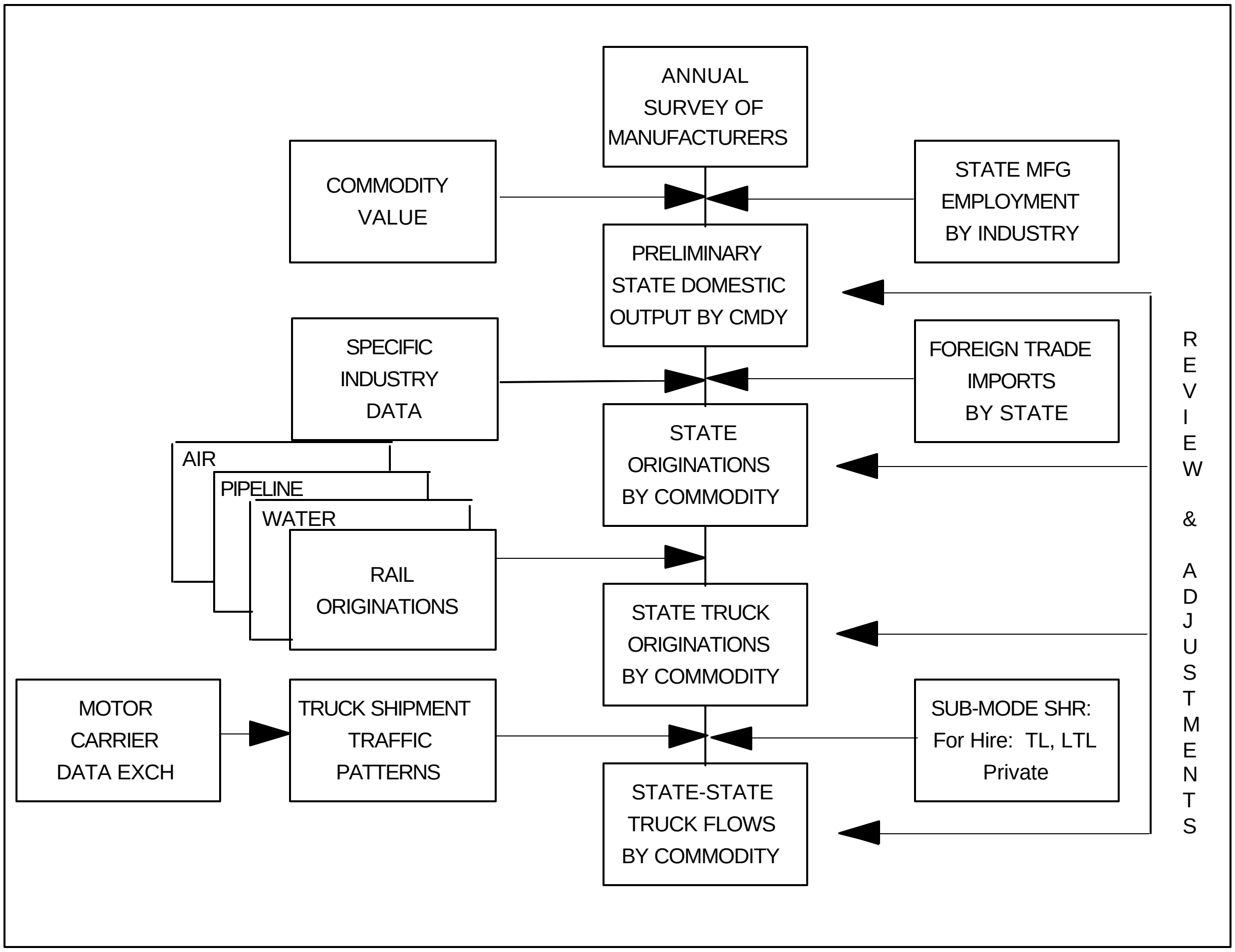
- Census/Annual Survey of Manufacturers
- Annual Bureau of Mines Commodity Reports
- Annual Motor Carrier Industry Financial & Operating Statistics
- Annual Railroad Freight Commodity Statistics
- Federal Reserve Board Industrial Production Indices
- Survey of Current business
- Trade Association Production and Shipment Reports
- Annual County Employment and Population Data
- State Economic Output By Industry
- Inter-Industry Trade Patterns (Input/Output Table)

1.1 Truck Flow Information

A graphic summary of the process for developing the truck information is shown in Exhibit 3-2. The primary underlying resources are the U.S. Commerce Department's

Census of Manufactures and Annual Survey of Manufactures, as shown in Exhibit 3-1. These sources provide the value of shipments for all manufacturing industries on a current basis. The information is converted to a tonnage basis using Reebie Associates' database of commodity values. At the same time production is distributed by state, based on relative employment levels within each industry. Employment data is drawn from an expanded version of Reebie Associates' Freight Locator Database of shipping locations.

Exhibit 3-2
Development of TRANSEARCH
State - State Flows



Once commodity production levels by state have been assembled, they are carefully reviewed and supplemented by reported state information as available. The adjusted domestic production level is then augmented by the volume of manufactured imports received at each of the state's ports. The resulting file represents the total volume of primary shipments of each manufactured commodity (defined at the three-digit NAICS level of detail) originated in each state. A variety of commodity/industry specific sources is also used in this effort. Information is derived from trade associations, industry publications and government agencies.

The level of truck activity is determined by subtracting known shipment volumes by competing modes. Rail, water and air volumes by state are derived directly from other elements of TRANSEARCH. Pipeline volumes, significant for only a handful of commodities, are developed separately from a combination of chemical/petroleum industry data, pipeline operating statistics and Census of Transportation (COT) data.

This process is reviewed and adjusted to eliminate impacts of secondary shipments (such as the barge loadings of potash imports in Minneapolis-St. Paul) within each state.

The differentiation among truck sub-modes (i.e., for-hire truckload, for-hire less-than-truckload (LTL), and private truck) is based on truck volumes reported in the Commodity Flow Survey, prior TRANSEARCH patterns, reported differences for imports and trucking industry data on the level of LTL shipments. Once the sub-mode volumes by commodity are determined, state-to-state flow patterns are derived from the Motor Carrier Data Exchange program.

1.1.1 Fresh Fruit and Vegetable Movements by Truck

The importance of fresh fruits and vegetables to the California transportation picture justifies a separate discussion of this commodity group. The rail and rail/truck intermodal section of the database comes from the California portions of the full railroad waybill sample. Truck shipments of fresh produce are developed from a variety of information sources developed by the Department of Agriculture (USDA). The starting point for the process is the annual report of shipment arrivals in 22 major produce market areas. These shipments are defined in terms of the state of origin, specific commodity, mode of transport, annual volume and destination city.

The first step in the process converts the USDA data from State/City flows to Business Economic Areas BEA/BEA flows. The conversion at the destination is direct, with each of the 22 cities corresponding to a unique BEA. In several cases, however, further allocations are required to segment the BEAs into their state components. For example, the New York USDA market corresponds to BEA 12, including portions of New Jersey and New York. These allocations rely on relative population levels and information on the locations of major produce wholesalers and food retailers' warehouses.

At the origin, the conversion from state to BEA utilizes data from USDA's Census of Agriculture. County production totals for fresh fruit and vegetable (FFV) commodities are extracted and used to compute county shares. The county shares are then aggregated along BEA lines to develop each BEA's share of the state output of specific commodities. These allocation shares are then applied to all state shipments of the corresponding commodity to generate flows with origins defined by BEA.

Once the development of shipments to the USDA's 22 city markets is completed, the next task is to expand the coverage to all BEAs. Shipments for an additional 17 BEAs are produced through an analysis which parallels that used for the initial 22 cities. These additional, typically smaller, markets were part of the USDA's reporting coverage in earlier years. Using the shipment patterns and relative volumes previously reported together with trends in population growth, current estimates are developed.

Truck shipments for the remaining BEAs are produced through a separate process, still relying upon USDA data sources. First, these BEAs are organized into a series of areas surrounding the primary FFV markets. The identification of each BEA with one of the primary markets serves two purposes. First, it provides a sourcing pattern for commodities shipped into the BEA (e.g., the relative roles of oranges grown in Florida and California). Second, the primary markets often serve as secondary origins, serving a surrounding hinterland. An overview of the procedures used to estimate shipment volumes from the producing areas to these hinterland markets is described below.

Estimated consumption levels by commodity are developed for all BEAs, including the primary markets, based on USDA per capita consumption data and population totals. For the primary markets, these volumes are then compared to the previously developed truck and rail (from the railroad portion of TRANSEARCH) termination totals by commodity. The difference between the predicted consumption levels and the shipment totals reflects reshipments to the surrounding hinterland BEAs.

Direct shipments from the growing areas to the secondary (hinterland) BEAs are calculated as the difference between projected total consumption and reshipments received from the primary, hub market. Given this level of demand by commodity to be satisfied by direct shipments from the growing areas, flow volumes are developed using the sourcing patterns experienced in the related hub market.

After flows into all BEAs have been estimated, the shipments are aggregated on a commodity, origin state and combined origin / commodity basis. These totals are compared to the corresponding summary USDA state production data. Iterative adjustments are introduced to ensure comparability between the TRANSEARCH truck FFV totals and those reported by USDA. California Agricultural statistics were used to capture produce that was processed. The assumption, again, was that California grown produce was distributed to food processors within the state.

1.1.2 Data Exchange - Truckload Information

Carriers that participate in the Motor Carrier Data Exchange program submit a summary of their annual traffic flows that includes origin state or zip code, destination state or zip code, 2-digit commodity, and tonnage. Most of the Motor Carrier Data Exchange information is now collected at the 3-digit zip code level. Some data are reported with greater (5-digit zip code) or less (state-level) geographic detail. All of this information is provided on an origin-to-destination basis. Zip codes are converted to counties as part of the database preparation process.

After an initial screening and analysis of the Data Exchange information, which adjusts and eliminates any discrepancies in reporting formats or procedures by the various participants, summary results are tabulated. The data are further checked and reviewed for uniformity, and a variety of statistics is derived to judge the reasonableness of the data. The most important numbers that are developed at this point are the sample rates by commodity at both the national and state levels.

The sample rates are calculated by dividing the amount of traffic reported by the Data Exchange carriers by the amount of traffic determined in our earlier processing (Step 1). Sample rates are calculated for each commodity at both the national level and for each state of origin. These sample rates are then used to determine the degree of adjustment that will be applied to the preliminary flows.

Adjustments are made to traffic flows based on the origin state and commodity. In addition, the zip code level information is translated to a county basis. This county-level information serves as a primary determinant of origins, destinations, and flows at the greater level of geographic detail.

1.1.3 Disaggregation

The basic TRANSEARCH framework requires that origins and destinations be defined in terms of States, BEAs, and counties. To conform to this format, the Stage 1 file must be disaggregated so that the origins and destinations represent the BEA areas within the State.

State-state flows are disaggregated in a two-step process. First, the origin State volume is broken down into its BEA components. This distribution is based upon the employment shares by county for the industry producing the specific commodity. Since this data is drawn from the same sources used in the Stage 1 process, full consistency is maintained in the Stage 2 disaggregation. For import flows, volumes are assigned to the BEAs where the individual port facilities are located.

A similar technique is used to develop county-level results. The information gathered from the trucking industry through the Motor Carrier Data Exchange program is also intensively utilized at this level.

Once the origins are redefined, the process shifts to the destination end. There the procedures are more complicated, because a given product may be shipped to a variety of industrial and non-industrial consumers. The key initial link in this analysis is information on inter-industry trade patterns: an Input/Output matrix. For any given product, the I/O Matrix indicates the relative amount consumed by each industry or economic sector. Based on the Commerce Department's I/O framework, TRANSEARCH uses an I/O Matrix from the Bureau of Economic Analysis that is updated to reflect the most currently available patterns.

In the TRANSEARCH disaggregation process, the portion of consumption related to industrial, mining or agricultural production is distributed to BEAs within each state on the basis of county employment shares for the relevant industries. Those portions of consumption attributed to personal, governmental or institutional usage are allocated by relative county population shares.

A hypothetical example of the Stage 2 disaggregation process is shown in Exhibit 3-3. The beginning point is a Stage 1 for-hire motor carrier truckload flow of 4 million tons of primary iron and steel products moving from Pennsylvania to California. At the origin, 55 percent of the State employment for the industry producing the product is located within the Pittsburgh BEA. As a result 2.2 million tons will be identified as moving from the Pittsburgh BEA to California. The remaining 1.8 million tons are assigned to other Pennsylvania BEAs.

A highly simplified breakdown of consuming industries contained in the I/O Matrix for NAICS 3312 is shown in the Exhibit 3-3, along with the Los Angeles BEA's share of California employment for each industry. The combined consumption share for the Los Angeles BEA is equal to the sum of the [(I/O Industry Share) * (BEA Employment Share)] for all the consuming industries. In this simplified example, no personal or government consumption is shown. Following this process, the Los Angeles BEA will be allocated 65% of California’s receipts of this commodity.

Applying this share to the 2,200,000-ton flow from the Pittsburgh BEA to California , the volume moving between the Pittsburgh and Los Angeles BEAs is set at 1,430,000 tons. The 2,570,000 tons remaining from the initial 4 million ton flow will be similarly allocated among the other BEA-BEA origin/destination pair combinations.

The example presents a highly simplified view of the process. In actual practice, many more individual consuming sectors are involved. The procedures must check, and adjust for, situations where consuming industries are not present within the destination area. The methodology also incorporates a length of haul impedance factor for intrastate movements and shipments between adjoining states. This procedure is essential to ensure that the methodology does not generate cross-shipping patterns when in reality demand is primarily satisfied by local production. In addition, the disaggregation process incorporates minimum volume criteria to prevent an unrealistic fragmentation of traffic flows.

Exhibit 3-3
Development of Truck Flows of Manufactured Goods

CONSUMING INDUSTRY NAICS	I/O SHARE (1)	LOS ANGELES BEA SHARE OF CA (2)	LOS ANGELES BEA SHARE OF FLOW (1) x (2)
3312, 3311, 3241	20%	80%	16%
3324	5%	75%	4%
3321	4%	95%	4%
3326, 3339	7%	60%	5%
3361, 3362, 3369	4%	65%	3%
MISC	60%	55%	33%
TOTAL	100%		65%

55% OF PENNSYLVANIA EMPLOYMENT IN NAICS 3312, 3311, 3241

PITTSBURGH BEA ⟶ CA FLOW

4,000,000 X .55 = 2,200,000 TONS

PITTSBURGH BEA ⟶ LOS ANGELES BEA FLOW

2,200,000 X .65 = 1,430,000 TONS

The process for disaggregating traffic at the BEA level to counties is similar to the one already discussed.

1.2 Railroad Traffic

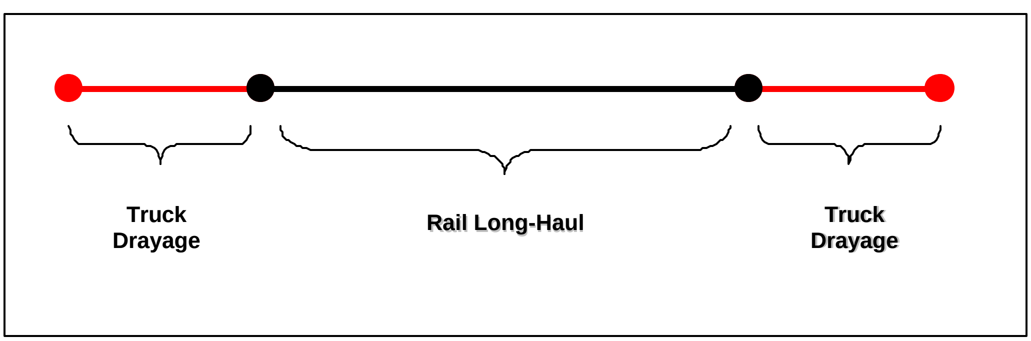
TRANSEARCH's rail traffic is developed from the public use version of the STB's annual Rail Waybill Sample file. The Waybill Sample is a statistically-based stratified sample of all shipments terminated by U.S. rail carriers. The full Waybill Sample file contains extremely detailed information on the origin, destination, commodity and volume of each sampled movement. California's access to the full Waybill Sample file has been used directly in the ITMS Freight Traffic Flow Database.

Throughout the development process, carload and trailer-on-flat-car / container-on-flat-car (TOFC / COFC) traffic are maintained as separate volumes. The identification of which shipments utilized TOFC / COFC services was based on the combined analysis of the car type, commodity and a series of TOFC / COFC data items in the public use file. The basic TRANSEARCH file contains TOFC / COFC movements just as they are reported in the public use file. Due to rebilling practices at major gateways, the reported flows can understate long-haul TOFC / COFC movements, while traffic in some short-haul lanes can be overstated. For example, a shipment moving from New York to Los Angeles may be reported as two separate movements: New York to Chicago and Chicago to Los Angeles.

1.3 Intermodal Freight

As illustrated in Exhibit 3-4, intermodal freight movements consists of both truck and rail portions. For the long-haul portion of the trip, the goods are carried by rail. The shorter, drayage, portion of the trip occurs on truck. Intermodal freight is generally reserved for very long freight movements. California intermodal trips occur primarily between California and other states rather than within California.

Exhibit 3-4
Intermodal Freight Movement



In the ITMS Freight Database, traffic that is classified as the mode “Intermodal” represents the rail portion of a truck-rail shipment. The origin corresponds to the point at which the shipment is put onto a rail car, and the destination is the point at which a shipment is taken off the rail car. This traffic is identified by the NAICs of the product, although much of this traffic is identified only as FAK (Freight All Kinds) in the primary source data (the STB Waybill Sample).

The ITMS Freight Database also captures the truck portion of the rail-truck intermodal shipments. This traffic is shown in the “truckload” mode, and is all identified by NAICs code 488000. This truck portion shows both the movement from ultimate origin (manufacturing) point to the railroad, and from the railroad destination to the ultimate destination point. On a tonnage basis, each intermodal shipment appears in the data set as three separate records, first as a “Truckload” mode movement of NAICs 488000, from true origin to the railhead, then as an “Intermodal” mode movement from one railhead to another, and finally as an additional “truckload” mode movement from the terminating railhead to the final destination point. On a ton-mile basis, the freight movement is counted only once.

1.4 Waterborne Commerce

The Corps of Engineers annually collects information on all shipments moving on the nation's waterways to support its management and planning activities. TRANSEARCH uses various components of the data issued by the Corps to develop its waterborne flow data.

The primary input is the annual COE file of water-borne commerce. This source provides state-to-state annual volumes of broad commodity groupings. Supplementing this flow data are originating and terminating volumes by port and more specific commodity type, which are also provided by the COE. The less detailed state-to state flow data is disaggregated to the port level using the more detailed origination and termination information.

Before converting the flows to the standard TRANSEARCH format, two additional steps are taken. First, a series of manual adjustments is made to crude petroleum flows originating in Alaska. Due to pipeline transshipments in Panama, flows originating in Alaska can be shown as having an unknown destination. Similarly, petroleum receipts at Gulf and Atlantic ports can be reported with an unknown origin. A manual matching of these flows is undertaken to provide a continuous picture of product flow. The second adjustment ensures that the database reflects the total volume on a commodity-by-commodity basis. The flows are aggregated along commodity lines and compared with published totals. Adjustments are made so that when all flows are summed, the results match the reported commodity totals.

1.5 Air Cargo

Air cargo represents by far the smallest portion, on a tonnage basis, of the TRANSEARCH database. Air activity is constructed using the Federal Aviation Administration's (FAA's) Airport Activity Statistics.

The FAA data reports the total tonnage originating at each airport. In addition, airport-to-airport flow volumes are reported by the FAA. The origin tonnage is then disaggregated into flows to the destination airport based on this second set of data. The data is then translated from airports to counties, based on airport location information that is also maintained by the FAA. In some case, where there is more than one airport in a county, the data is subject to a further aggregation.

Commodity identification is then introduced. The Commodity Flow Survey provides a broad level identification of commodity types. This broader detail is further refined based on the production, for the origin, and consumption, for the destination, levels using full detail commodity information for each market.

2. MEXICO/U.S. FREIGHT MOVEMENT DATA

TRANSEARCH International databases complement the U.S. domestic freight traffic flow data available in the proprietary Reebie Associates TRANSEARCH database. The two TRANSEARCH International databases are the one for Mexico / U.S. trade, which is the most recent, and the one for Canada / U.S., which was first produced for data year 1988.

While Mexico has always been an important trading partner for U.S. commercial interests, it is only recently that reliable statistics on U.S. / Mexico trade have been made available in a detailed form. Reebie Associates published a compendium of facts on U.S. / Mexico freight movements several years ago, and some of the sources used in that effort became useful as cross-references in processing the newly acquired data.

Although Texas leads all U.S. states in terms of trade with Mexico, California is a clear second and is far ahead of all remaining U.S. states. For example, 1990 statistics show that for southbound freight movements (i.e., exports to Mexico), California represented approximately nine percent of total U.S. shipments. The next largest group of three U.S.-origin states were clustered at approximately 4 percent each. California's chief export items to Mexico include petroleum products, farm products and processed food products.

Maquiladora plants have sprung up all along the U.S. / Mexican border, but the highest concentration is just across from California (i.e., at Tijuana and Mexicali). Recent counts show that Baja California has some 45 percent of the total Maquiladora plants in Mexico, and Baja California combined with Sonora represents 51 percent of the total. California is unquestionably one of the most important market areas for Mexican imports and exports.

2.1 Basis/Specifications

This TRANSEARCH-International database complements the domestic U.S. and Canada / U.S. versions of TRANSEARCH used by numerous U.S. carriers and planning agencies since 1980. The new Mexico-U.S. database bears the following specifications:

Modes of Transport:	Truck and Rail
Commodity Detail:	3-digit STCC Groups
Geographic Markets:	States; U.S. (48) and Mexican (32)
Time Period:	Annual, 1996 base year
Volume Units:	Tons

2.2 Sources

The central source of the TRANSEARCH-International database is a set of monthly U.S. / Mexico transborder statistics produced by the U.S. Bureau of the Census, under contract to the Federal Department of Transportation's Bureau of Transportation Statistics. This source provides information on transborder shipments in terms of declared value (U.S. dollars) at customs inspection points on the border. Information on southbound shipments includes U.S. state of origin and Mexican state of destination. For northbound shipments, U.S. state of destination is shown, but origins are shown simply as Mexico. Commodities are indicated by the Mexican version of the "harmonized" coding system.

Several adjustments are required to develop a database that is comparable to pre-existing TRANSEARCH products in level of detail and consistency of definitions. To this end, and for cross-referencing, a number of other sources are used.

2.3 Processing of the Data

Processing the data involves conversion to STCC commodity codes, conversion of volume units from dollars to tons, allocation of northbound traffic to Mexican state of origin, and additional adjustments to apply seasonality factors.

2.3.1 Conversion to STCC Commodity Codes

To standardize the commodity definitions to conform to the domestic U.S. and Canada / U.S. TRANSEARCH data, the Mexico / U.S. data are converted from harmonized code to Standard Transportation Commodity Classification (STCC) form. This is done by creating a bridge table (i.e., manually printing out a list of all commodity groups in the source data and assigning each group to a 3-digit STCC equivalent). After a second review, some further checks are made during the process of converting volume units from dollars to tons. Adjustments are made in some instances where the dollar value is deemed more appropriate for another STCC category.

For the ITMS Freight Database, a further conversion of the commodity codes from STCC to NAICs is made.

2.3.2 Conversion of Volume Units from Dollars to Tons

The basic information is expressed as volume in U.S. dollars. A conversion is made to tons using a table of product values (i.e., U.S. dollars per pound for STCC groups to the 4-digit level of detail). As mentioned above, some individual checking is performed where there are possible ambiguities or areas of sensitivity.

A further adjustment is made for northbound U.S. imports from Mexico. This is to compensate for the fact that many or most manufactured items coming into the U.S. from Mexico are predicated on the fact that production is cheaper in Mexico and they can be brought into U.S. markets at a lower cost to the distributor. A 25-percent, across-the-board reduction was established and applied to manufactured items coming northbound. This is consistent with explanatory notes received from the provider of the data, the U.S. Bureau of Transportation Statistics. It was also checked with an economic consultant in Mexico City and who confirmed that it is a reasonable approach. The result is an increase in the tonnage, due to the presumed lower dollar value per ton for the northbound shipments.

2.3.3 Allocation to Mexican State of Origin for Northbound Traffic

To the Mexican state of origin for northbound shipments, source data is processed further. The methodology employed hinges on a set of tables produced by Reebie Associates from a variety of other sources in 1992. These tables give a quantified breakdown of all 32 states within Mexico as origin areas for world exports from Mexico. Further, each table represents an industrial group, approximating a two-digit STCC code. It is assumed that Mexican exports to the U.S. are proportionately in the same source patterns as exports to the rest of the world.

2.3.4 Further Adjustments

Certain seasonality factors are applied, especially for agricultural and food products, to attain a more reasonable picture of volume of freight activity for the full year. One of the main reasons is the existence of a transport mode identified as "Other."

The "Other" mode is more accurately described as an "Unknown" mode. This is a direct reflection of the government's data collection techniques. In some of the Customs documentation, from which this data is drawn, the specific mode was not identified. In late 1993, this miscellaneous category accounted for as much as 56 percent of the total volume. Improvements by the government in their recording and tabulation of this documentation for the cross-border trade have lead to a reduction in the use of the "Other" classification. In first quarter of 1994, this was reduced significantly, but remained at problem proportions. By April 1994, however, the "Other" had been reduced to below 15 percent and continues to shrink as more of the traffic is now being categorized as either truck or rail.

3. CANADA/U.S. FREIGHT MOVEMENT DATA

Statistics Canada is the arm of the government charged with the collection of statistical information on Canadian institutions. The International Trade Division of Statistics Canada compiles and develops import and export trade figures for movements of freight between the U.S. and Canada. Data include information about origin, destination, commodity classification, mode of transportation, quantity (where available), value, and province of clearance.

Information in these data files is configured into a transportation orientation. Records are read and sorted into an origin / destination format. Canadian location codes are converted to Reebie codes. Different weight measures are translated to short tons. When only values exist, they are also converted, first to U.S. dollars and then to short tons.

3.1 Specifications

Geographic Markets:	U.S. Counties; and Canadian CMAs
Commodity Detail:	4-digit Standard Transportation Commodity Code (STCC)
Modes of Transport:	Rail, Truck, Water, Air, Other
Time Period:	Annual, 1996
Volume Units:	Short tons

3.2 Processing of Data

In the raw data that is obtained from StatsCan, all origins and destinations are defined as U.S. states or Canadian provinces. Northbound movements from the U.S. to Canada show province of customs clearance, which may differ from the location where the goods are actually consumed. The U.S. state codes are FIPS (Federal Information Processing Standards) codes developed by the federal government. The codes for Canadian Provinces are assigned by Reebie Associates. The "state of export" is not always the state of the commodity's origin, nor is the "province of clearance" necessarily the same as "province of final destination."

The Harmonized Commodity Description and Coding System (HS) is a tariff classification system developed for product classification for international freight movements. The international agreements require the first six digits of the code to be consistent from country to country. For the Canada / U.S. freight flow database, these have been translated into equivalent four-digit STCC definitions.

Five separate modes are reported: truck rail, water, air and other. Where the mode of transport is unknown or not clearly specified on the customs documents, the shipment is included in the "other" grouping. The "other" category, however, is overwhelmingly dominated by pipeline shipments of crude petroleum and natural gas.

In cases where more than a single mode is involved in a movement, modal definitions may not always fit expected or logical patterns. For example, some potash shipments move by rail from Saskatchewan to Thunder Bay and then by ship into a U.S. port city. The movement would be reported as a water shipment, even though Saskatchewan contains no port facilities.

Canadian customs documents (from which the data are derived) typically include information on value of the shipment and quantity of goods moved. Although the value measure is consistent across all commodities, the units used to report the quantities vary widely. Some goods are reported as kilograms or metric tons, but others are measured in gallons, square feet or simply "number" of units.

Where valid weight measures (e.g., grams, kilograms or metric tons) are reported, tonnage conversions are based on the physical units. In the other cases, tonnage levels are computed from shipment value data, using commodity prices for individual, four-digit STCCs. Thus, where there are no weight measures, the value given in Canadian dollars is converted to U.S. dollars using the Bank of Canada's annual average exchange rate. Then the HS code is translated to a STCC. With the STCC code in hand, the program consults the U.S. dollars / pound bridge and calculates the tons based on that value.

Once the database has been constructed, the information is reviewed and two types of adjustments are made. Major shifts from prior year volumes are analyzed for possible errors in source document reporting and any necessary adjustments are made. In addition, reported air cargo movements are reviewed for anomalies such as bulk commodities moving in large volumes by air. Where such unlikely flows exist, the modal definition for the flow is changed from “air” to “other.”

For U.S. origins and destinations, domestic traffic volumes at the county-level are used to allocate the international origins and terminations. On the Canada side, a separate information on intra-Canada truck and rail flows serve as the basis for the allocation. This data is also compiled by StatsCan, and is gathered through surveys of their domestic trucking and rail industries.

4. NON-MANUFACTURED FREIGHT TRAFFIC ACTIVITY

Motor carrier traffic in California from non-manufacturing sources totaled over 240 million tons in 1996. This is equal to over one-third of the over 650 million tons identified in the TRANSEARCH database as truck traffic from the manufactured and merchandise sectors. Clearly, ignoring non-manufactured freight traffic would eliminate a large portion of truck traffic from any planning analysis.

The ITMS Freight Database adds five basic components to ensure that non-manufactured freight traffic is included. These components consist of agricultural products, timber, unprocessed minerals, municipal wastes and secondary shipments. For this project, a breakdown of the items is as follows:

Component	**1996 Short Tons (000)**
Agriculture	
Sugar Beets (NAICS 111190)	25,969
Rice & Wheat (NAICS 111140)	4,681
Milk & Livestock (NAICS 112112)	6,004
Cotton (NAICS 111920)	607
Poultry & Eggs (NAICS 112310)	65,274
	102,535
Timber (NAICS 113100)	**10,228**
Minerals (NAICS 212300)	**57,397**
Includes: Clay	
Decomposed Granite	
Limestone	
Sand & Gravel	

Stone	
Municipal Solid Wastes	
To landfills	32,879
To recycle	8,468
	41,347
TOTAL	**211,507 tons**

There are other items, such as fish, that would fit into this non-manufactured classification, but the development of useful input data is too time consuming for the relatively small tonnage involved. In some instances, the data were available but the tonnage was too small to be of any consequence. In mining and minerals, the four items accounted for well over 90 percent of the total activity.

4.1 Basic Approach

In each commodity grouping, the same procedure was followed for developing county-to-county traffic flows. The essential requirement was to identify people and organizations who maintain relevant data and are knowledgeable about the products in question and the distribution channels they employ. The Transportation Planning Program in the California Department of Transportation provided this essential conduit.

Caltrans provided assistance in identifying the appropriate state agencies to contact for each of the different non-manufactured products or industries covered. These are generally the organizations listed in the "Contacts" sub-sections, and in some cases in the "Sources" in the sections that follow. The "Sources" provided actual data, and the "Contacts" were the resources who helped piece together the series of movements and types of destination or intermediate points in the distribution chain for the non-manufactured goods.

In no instance was there a ready source of specific origin-to-destination moves for the products that were a part of this study. Generally, origin information at the county level was available and after the confidentiality issue was bridged, it was made available, typically in machine readable form. Destination information was another matter. Certainly, there was no direct tie of origins with specific destination. In fact, the warning was repeatedly made that developing logical allocation approaches might only have an incidental relationship to reality.

The solution to the lack of specific flow information was an attempt to gain a quantitative view of the distribution channels employed to the point where the product was consumed, processed or manufactured. At that point, it is captured in TRANSEARCH. Unfortunately, there were too many times when products moved more than once before they reached their destination or were otherwise captured in the transportation picture. Cattle, for example, can move to auction markets and from there to packing plants, feed lots or back to grass. Each of these steps was played out in terms of transportation activity.

Once destination points were identified, it was necessary to develop an algorithm to define the facility's ability to consume or absorb inbound product. Then consideration had to be given as to what would most likely be its drawing area. Neither set of information is readily available.

Various surrogates and estimates of capacity were used for each of the products. These, in turn, were translated into percentages relating to the 1996 volume moved (or received). Other than a few anecdotal transportation stories, there was no distribution approach or algorithm which was readily available. Consequently, the basic rule was to have the local supply of product handled first by location(s) within the same county. Then the surpluses (added tonnage to be moved) or the deficits (capacity available for added consumption) were calculated. Starting with the largest surplus areas, volumes were distributed to the closest consumption points, starting with adjacent counties. The process continued to the next largest surplus and then to the next until the distribution was completed. The implication is that the largest production areas received priority in terms of closest consumption markets.

In all cases it was assumed that products of California were consumed in California. This was a necessary assumption but not altogether true. In the past, information was maintained on the number of cattle moving into the state from outside locations. Much of this information is not being updated, even on a sample or periodic basis.

4.2 Sugar Beets

Sugar beets are raised over a wide area in California. Total production for 1996 was nearly 26 million tons. The root of the sugar beet is harvested for its sugar content (about 15 to 20 percent of the weight of the root). Once at the factory, the root is washed, cut into cossettes and soaked to remove the sugar. The resulting solution is treated, filtered and then evaporated to allow crystals to form. The cossettes are used in cattle feed. The green leaves and short stem of the plant are separated from the root at the time of harvest and usually are fed to livestock or are used as fertilizer.

4.2.1 Assumptions and Procedures

The allocation process allowed for product to go to contiguous counties with excess capacity first, moving outward from the source county. Highest production received preference (i.e., product remained closer to the source). The exception would be cases where such a small amount (less than one truckload per week) was to be allocated that it was judged unrealistic for owners to move it great distances. All product raised in California remains in California.

4.2.2 Sources

Steinkamp, Myrna P. "Sugar Beets." The World Book Encyclopedia. 1993 edition.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

Wyse, Roger E. "Sugar." The World Book Encyclopedia. 1993 edition.

4.2.3 Contacts

California Department of Food and Agriculture. 916-654-0919.

4.3 Rice

For the purposes of freight movement, it was assumed that all rice moved into storage from the field. The total 1996 production of NAICS 111140, which includes both Rice and Wheat, was 4.7 million tons. From storage about 83 percent goes to milling facilities and the remainder is exported from California ports. Waterborne Commerce Statistics data show that rice is exported through two southern California ports (i.e., Long Beach and Los Angeles) and three in the north (i.e., Sacramento, San Francisco and Oakland).

4.3.1 Assumptions and Procedures

The allocation process allowed for product to go to contiguous counties with excess capacity first, moving outwards from the source county. Highest production got preference, i.e., product remained closer to the source. The exception would be cases where such a small amount (less than one truckload per week) was to be allocated that it was judged unrealistic for owners to move it great distances. It was also assumed that all product raised in California remains in California.

4.3.2 Sources

Rutger, J. Neil. "Rice." The World Book Encyclopedia. 1993 edition.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

4.3.3 Contacts

California Department of Food and Agriculture. 916-654-1429.

4.4 Wheat

Wheat is one of California's leading field crops. The total 1996 production of NAICS 111140, which includes both Rice and Wheat, was 4.7 million tons. For the Caltrans ITMS project, the assumption is that all wheat is shipped from farm to storage. From storage, 42 percent of wheat goes to be milled, 50 percent to export and the remaining eight percent is used for cattle feed.

4.4.1 Assumptions and Procedures

Thirty-five counties in California were identified as having grain and soybean storage facilities. Capacity was set equal to total California production for the 1996 crop year. Using percent of total for each county, capacity in tons was calculated and the wheat was allocated from field to storage.

From storage, wheat moved to one of three stages: milling, export, or feed lots/yards. As with storage, milling facilities were identified by SIC code. Capacity was estimated and was assumed to be entirely used.

According to a spokesperson at the California Department of Food and Agriculture, about 50 percent of California's wheat is exported, although not all of it is exported through California ports. For purposes of developing the ITMS Freight Database, since no quantification was available, all California wheat exported is assumed to go through California ports. Export figures were taken from the Waterborne Commerce Statistics. Allocation was based on the ratio of total wheat exported from California ports to that grown in California.

Information on locations of feed yards was taken from a directory issued by the California Department of Food and Agriculture. The California Wheat Commission (CWC) estimates that about one-third of California grain goes to export, one third to mill and one third to feed. According to the CWC, about 20 percent of wheat stored in any given year is stored on farms. The largest portion of the crop moves directly from field to mill, export or feed. That stored off-farm (close to 10 percent) is at mill, elevator, terminal and warehouse locations. From there, wheat goes about equally to mill, export or feed.

4.4.2 Sources

California Department of Food and Agriculture, Bureau of Livestock Identification. Registered Feedyard Directory 1994. Sacramento, revised 11/15/94.

Croy, Lavoy I. "Wheat." The World Book Encyclopedia. 1993 edition.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

4.4.3. Contacts

California Crop Improvement Association. 916-752-0544
California Department of Food and Agriculture. 916-654-1429
California Grain and Feed Association. 916-441-2272
California Wheat Commission. 916-661-1292

4.5 Milk

As the Economic Research Service observes in its Agricultural Information Bulletin Number 474, "Milk, which is bulky, highly perishable, and subject to bacterial and other contamination, must be produced and handled under sanitary conditions...." Raw milk is generally stored by farmers in refrigerated tanks. Most commonly, dairy cooperatives send out tank trucks to member farms to pick up the milk and take it to a plant to be processed. It is then sold for drinking or manufactured into storable dairy products. The 1996 production of NAICS 112112, which includes Milk and Livestock, was 6 million tons.

4.5.1 Assumptions and Procedures

For purposes of allocation, it was assumed that all milk is processed off the farm. After processing, about 38 percent of all milk designated as Grade A milk is sold as fluid milk. Another 47 percent of all milk classified as Grade A is sold for use in manufacturing. The 15 percent of milk produced that is classified as Grade B, or manufacturing grade, is utilized in manufactured products such as butter, nonfat dry milk and cheese.

Milk was assigned to the processing county closest to the production county. Where counties had excess processing capacity, those with the highest production were given preference (i.e., product remained closest to the source). Thus a county with medium production levels might have its milk allocated to a processing county further away. An exception was made for counties where production amounted to less than one truckload per week. These were assigned to the closest county in the region.

4.5.2 Sources

California Department of Food and Agriculture. California Dairy Industry Statistics 1992: Manufacture of Dairy Products, Milk Production, Utilization and Prices. Sacramento: U.S. Department of Agriculture, National Agricultural Statistics Service, no date.

Marshall, Robert T. "Milk". The World Book Encyclopedia. 1993 edition.

U.S. Department of Agriculture, Economic Research Service. Dairy: Background for 1985 Farm Legislation. Washington, D.C., 1984.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

4.5.3 Contacts

California Department of Food and Agriculture, Milk Stabilization Branch, California Agricultural Statistics Service. 916-654-0773

Candace Gates, CA Department of Food and Agriculture. 916-654-0905

U.S. Department of Agriculture, Kevin Hinstzman. 202-720-4448

4.6 Cattle and Calves

Data regarding cattle and calves were given as total number of each sold. Utilizing the Agricultural Statistics, the U.S. average live weight per cow (1169 pounds) and the average live weight per calf (376 pounds) was used to determine tons to each county. The tons per cattle and calves were added together to produce total tons. The 1996 production of NAICS 112112, which includes Milk and Livestock, was 6 million tons.

4.6.1 Assumptions and Procedures

The Bureau Chief of the California Department of Food and Agriculture identified counties that had auction markets and provided broad estimates of their capacity. Each county's tonnage was determined and their percentage of total was calculated. The resulting list of counties was ranked by tonnage of cattle moved out of or accepted into auction facilities. For the counties without auction market facilities, the tonnage was allocated to the closest county that had available capacity.

According to the Department of Food and Agriculture's Bureau Chief, 50 percent of all cattle goes directly to auction markets. The remaining 50 percent, which also goes through auction markets, is divided evenly between slaughter houses, feed yards, and grass. These flows were then allocated in the same manner as the auction markets. They were calculated and included in the database.

4.6.2 Sources

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

U.S. Department of Food and Agriculture, Bureau of Livestock Identification.

4.7 Cotton

Data about production of cotton by county was taken from the 1997 Census of Agriculture for California. Quantity was given in bales. The approximate net weight of a cotton bale is 480 pounds (lint). According to Agricultural Statistics, "the bale of cotton is 500 pounds or 480 pounds net weight.....Actual bale weights vary considerably...."

After it is harvested, cotton goes to a gin to be cleaned and to have seeds separated from the lint. A baler press packs it into 480 pound bales, which are covered and bound by steel ties. At this point each bale is about the size of a household refrigerator. To increase the number of bales that can be loaded into trucks or rail boxcars, each bale can be compressed, using special machines, to about half its original size. From the gin, baled cotton lint is trucked to warehouses to be stored. From there some goes to mills in the United States and the remainder is exported. The total production for 1996 was 600,000 tons.

4.7.1 Assumptions and Procedures

Gins are generally located 15 to 20 miles from the field. Therefore all gins were assumed to be located in the same county as the production. From gins, bales go to warehouses. Warehouses were considered to have equal capacity. Tonnage was allocated according to distance from the producing county and, where there was an overflow, cotton from the largest-producing counties was allocated to the warehouse county closest to them.

From the warehouses, cotton is shipped to ports to be exported or to mills in the Southeast U.S. From each, 70 percent of the crop moves to export through California ports and the remaining 30 percent remains in the domestic market.

According to the California Cotton Cooperative, 70 percent of the crop is exported through Oakland or San Francisco and Los Angeles or Long Beach. To allocate cotton to the counties where ports are located, we used data reported for those ports by the Waterborne Commerce Statistics Center. The percentage of the total cotton tons moving through each of these ports was calculated and applied to California's crop for that year. It was assumed that all California cotton was exported through California ports.

4.7.2 Sources

U.S. Department of Agriculture, Economic Research Service. Cotton: Background for 1985 Farm Legislation (figure 3: "Distribution of an Average Bale of U.S. Cotton"). Washington, D.C.: U.S. Department of Agriculture, 1984.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

Wellford, Dabney S. "Cotton." The World Book Encyclopedia." 1993 edition.

4.7.3 Contacts

California Cotton Marketing Cooperative, Bakersfield, CA 805-327-5961
National Cotton Council, Memphis, TN 901-274-9030

4.8 Poultry

The 1996 production of NAICS 112310, which includes Poultry and Eggs, was 65 million tons.

4.8.1 Assumptions and Procedures

Using the total number of turkeys, hens / pullets, and broilers sold in each county in California for the year 1996 and Dairy and Poultry Statistics on the average weight per turkey (21.2 pounds), per broiler (5.1 pounds) and per hen / pullet (3.8 pounds)he tons to be shipped to each county were determined.

All tonnage went through processing plants. For the counties without their own facilities, their tonnage was allocated to the closest county that did.

4.8.2 Sources

U.S. Department of Agriculture. Poultry Production and Value, 1993 Summary.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

4.9 Eggs

California leads the U.S. in egg production. Figures for eggs laid in California in 1996 are based upon 254 eggs per year per layer, according to a spokesperson at the U.S. Department of Agriculture, National Agricultural Statistics Service (NASS) field office in California. Agricultural Statistics 1993, Table 519, estimates that 30 dozen eggs weigh 47 pounds on average. Forty-eight counties in California had hens/pullets of laying age. Another eight counties had too few producers to allow disclosure of figures.

After they are gathered, eggs must be cleaned, inspected for imperfections and graded. Some farms have facilities that are equipped for these tasks. In other cases processing is done off the farm. Those eggs that go to market as shell eggs are packed for shipping and moved to wholesalers and retailers, sometimes via warehouses. To the point of display, they must be refrigerated to 45 degrees Fahrenheit. About 11 percent of production are “broken” and utilized in processed foods.

The 1996 production of NAICS 112310, which includes Poultry and Eggs, was 65 million tons.

4.9.1 Assumptions and Procedures

It was assumed that all eggs went off farm to handlers/distributors for cleaning and grading. Capacity was set equal to total California production for allocation purposes. Using percent of total for each county, capacity was calculated in tons. Eggs were allocated to these facilities.

A spokesperson from the California Egg Commission estimated that approximately 89 percent of eggs then moved to handlers/packers. Often these are warehouses belonging to supermarket chains. Others supply institutions, schools and the military. The remaining 11 percent of the cleaned and graded eggs are destined for egg breakers facilities. Of this amount, approximately nine percent remain in the same facility for breaking. The remaining two percent is moved off-site to egg processors/breakers. Here eggs can be processed to produce liquid, frozen and dried egg products. For this analysis, all were assumed to be facilities that the two percent of eggs would travel to. The same procedure described above was employed to estimate capacity and allocation locations. Eggs arrive as non-manufactured commodities, but the products that leave the facilities are classified as manufactured items.

4.9.2 Sources

Austic, Richard E. "Chickens." The World Book Encyclopedia. 1993 edition.

Hobson, Burton H. "Poultry." The World Book Encyclopedia. 1993 edition.

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5: California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

4.9.3 Contacts

Robert Pierre, California Egg Commission, Upland, CA 909-981-4923

James Tippett, U.S. Department of Agriculture, National Agricultural Statistics Service, California field office. 916-498-5161

4.10 Sheep and Hogs

Sheep and hogs account for over one million tons shipped from California farms to slaughtering and packing houses. The 1996 production of NAICS 112112, which includes Milk and Livestock, was 6 million tons.

4.10.1 Assumptions and Procedures

Data for sheep and hogs were given as total number sold for each county. For the year 1996, the total number of sheep and the total number of hogs going to each county was recorded. Utilizing the Agricultural Statistics, the U.S. average live weight per hog (252 pounds) and the average live weight per sheep (125 pounds) was used to determine the tons originating for market to each county. The tons per hogs and sheep were added together to produce total tons to be transported per county.

For each county, the estimated production and the percent of total was calculated. This resulted in a list of counties ranked as to whether they had sheep and hogs that they could receive or move out to another facility.

The sheep and hogs were distributed among the state's meat packing plants. Sheep and hogs to be moved were shipped to facilities within their respective counties and if quantities remained, these were moved to the closest county with available capacity.

4.10.2 Sources

U.S. Department of Commerce, Bureau of the Census. 1997 Census of Agriculture, Volume 1: Geographic Area Series, Part 5 : California State and County Data. Washington, D.C.: U.S. Government Printing Office, 1999.

U.S. Department of Food and Agriculture, Bureau of Livestock Identification.

4.11 Forest Products

Forests cover about 40 percent of California. The state has two main timber regions, each named for an important tree in the region. The Redwood Region is a narrow belt that extends south along the coast from Oregon to San Luis Obispo County. The Pine Region covers the Cascades and the Sierra Nevada and extends along the inland parts of the Klamath Mountains and the Coast Ranges as far south as Lake County.

The forests are an important resource for California. They are used for timber production and for recreation. They are especially important for preserving the state's water supply as water does not run off or evaporate so quickly in forest areas. The total production for 1996 was just over 10 million tons.

4.11.1 Assumptions and Procedures

For purposes of allocation, species were divided into two groups. It was assumed that Christmas trees and woodchip would not go to the mills, and these products were allocated by county population. All other species were allocated to areas where mills are located. The percentage of total was determined from yearly boardfoot production and applied to the volumes to be allocated.

In both cases, counties accepted their own volumes first and excess volumes were then assigned to the closest available county.

4.11.2 Sources

Database (File YTR92.DBF) from the Timber Tax Division

Board of Equalization, Timber Tax Division. Species Codes and Units of Measure for Timber Tax Returns.

Board of Equalization, Timber Tax Division. Forest Products Conversion Factors.

Directory of the Woods Products Industry (listing of mills in California).

4.12 Mines

California is one of the largest producers in the nation in terms of the total value of non-fuel mineral production. It is the sole producer of boron and tungsten, and leads all states in the production of asbestos, portland cement, diatomite, calcined gypsum, rare-earth concentrates, and construction sand and gravel. There are mines in almost every county in California. Clay, decomposed granite, limestone, sand and gravel, and stone, make up most of the state's total tonnage. Total mineral production in 1996 was 57 million tons.

4.12.1 Assumptions and Procedures

Using the 1996 Mineral Commodity Statistics from the Bureau of Mines, we found that, with the exception of clay, the commodities are used mainly for construction, roads and railroad ballast. Clay is used for brick and pipe.

There are no available sources tracking where the commodities go after leaving the mines. Reebie Associates spoke to several people in the industry who gave us their impressions of how each commodity is used. It was agreed that about 65 percent of the tonnage covered residential construction and railroad ballast. The remaining 35 percent was used in road work.

Based on these conversations, the following allocations were made: for the 65 percent used n residential construction and railroad ballast, county population was used to allocate tonnage to counties. The remaining 35 percent was allocated using data on county expenditures and annual financial reports on road work.

Clay was allocated separately. Using Reebie Associate's Freight Locator, all companies manufacturing brick and pipe were identified. The size and location of each company was used to allocate clay to counties.

4.12.2 Sources

U.S. Bureau of Mines. 1996 Mineral Commodity Statistics.
U.S. Bureau of Mines. Mineral Industry Surveys. Prepared 11/08/93.
Annual Report 1992-93, Financial Transactions Concerning Streets & Roads of California.
California Department of Transportation. Annual Financial Statements and miscellaneous statistical reports, Fiscal Year 1992.

4.12.3 Contacts

Denise Jones, Director, California Mining Association. 916-447-1977
George Cope, President, Aggregate Producers Association of Northern California. 916-443-5353
Susan Cohler, State Geologist. 916-322-2719

4.13 Waste

The California Integrated Waste Management Board was formed in 1990 in response to concerns regarding management and disposal of solid waste in California. Each California city, county or regional agency is required to report to the Board the status of their efforts to establish waste diversion programs. The mandate was to divert 25 percent of each area's solid waste from landfill and transformation facilities (and 50 percent by the year 2000).

The Board anticipates that statewide, California will achieve the diversion mandate. Since the Act became effective in 1990, the number of programs implemented has increased by 155 percent. The data submitted are based on five program categories: residential recycling, commercial recycling, composting, special wastes and private sector activities. The most notable increase came in the compost category, where programs increased 487 percent between 1990 and 1994. The total volume of waste transported in 1996 was 41 million tons.

4.13.1 Assumptions and Procedures

In the actual allocation process, all counties first absorbed their own waste. overflow was moved to the nearest county possible.

4.13.2 Sources

California Integrated Waste Management Board Database Project, 1990.
Tons of Non-Hazardous Solid Waste Accepted at Solid Waste Landfills in California, 1991 - 1994.
Reebie Associates' Freight Locator.

5. SECONDARY SHIPMENTS

Secondary shipments are distinguished from primary shipments in that they are steps in the distribution pipeline where a movement occurs before or after the major trip has taken place. These are generally relatively short-haul truck movements. Examples of secondary moves would include shipments into or out of warehouses, distribution centers or certain terminal facilities. The prior or subsequent moves may involve different modes of transportation, but the product carried is physically the same as it was for the primary stage.

In commercially available TRANSEARCH database, primary moves may be thought of as shipments originating at locations where a product is first produced or assembled and receives its Standard Industrial Classification (SIC) number. The terminations of these shipments are where the product or commodity first comes to rest, either to be consumed or subjected to further processing. If the product moves to a warehouse and is mixed with other products of a similar nature and then reshipped, from a data source perspective it is difficult to identify that second move.

A number of major motor carriers participate in a data exchange program that aids in the development of TRANSEARCH. Some of these carriers, both for truckload and less-than-truckload moves, have been able to supply information on secondary shipments they have carried. This source has provided significant input to help address the question of the extent of secondary shipments.

In addition, locations of warehouse facilities are compiled from the Freight Locator database, and from information provided by the Public Warehouse Association. Based on employment levels and facility size (square footage, number of doors), Reebie has developed algorithms to estimate each facilities output. This data is a standard feature of the TRANSEARCH / Intermodal Freight Database.

Two other distinct components of secondary traffic are also included, and again these are now standard elements of the TRANSEARCH / Intermodal Freight Database. These are the truck portion of rail / highway intermodal movements, and the truck drayage of air freight shipments.

The patterns of truck movement for the truck portion of rail / highway intermodal activity are developed using data collected from several of the leading firms in this industry through our Data Exchange programs. For the air freight drayage, flows are creating using an econometric process that is based on classifying each county into a service area for each airport.

6. EMPTY TRAILER MOVEMENTS

A significant component of highway and street truck traffic volumes are empty moves. While minimizing empty movement is crucial to the success of long haul motor carriers, not many studies on this topic have been published. The ratios used in the California database are based on a 1976 study by the Interstate Commerce Commission, supplemented by work with motor carriers.

The ICC's "Empty/Loaded Truck Miles on Interstate Highways during 1976" broke down the number of truck movements loaded and empty by basic equipment type, ICC authorization, interstate versus intrastate, owner operators versus non-owner operators and by region of the country. The missing element was percent of empty activity by length of haul.

The following default factors have been used to estimate empty movement activity:

MILES	VAN	FLATBED	BULK
100	45%	50%	50%
200	30%	32%	45%
400	18%	22%	40%
800	16%	19%	37%
1,200	10%	14%	35%
2,200	4%	8%	30%

7. FORECASTS

To add perspective to California's freight traffic patterns, forecasts have been prepared for three time periods: 2006, 2016 and 2026. In each case, the forecast has been based on projections from an origin perspective of the traffic. While the forecasts applied to the database are placed in the context of national projections of trends and changes in economic growth, the projections are also developed for the state level.

By their nature, however, traffic flows have a distinct spatial orientation. That is, changes in activity levels implicitly involve both an origin and a destination. Not only does an origin market have more or less goods to ship according to the drivers of a forecast, but applying the changes to past trading partners implies that their demand for goods will rise or fall proportionally to the origin area. Obviously not all geographical areas of the economy rise and fall at exactly the same rate. This dimension is not included in the forecasts presented in this project. Fortunately, in the case of California, over 70 percent of its traffic originates and terminates within the state. Interstate activity will show some shifts in trading partners over these time periods.

The ITMS Freight Database relies on two sources for its forecasts of future freight activity: DRI and county-level forecasts produced by the Caltrans Transportation Economics Unit. The DRI information shows growth by 2-digit commodity group, by state, on both an origin and destination (production and consumption) basis. The Caltrans County Forecasts show production at a county level.

For over 30 years, DRI has been forecasting economic activity at the industry (U.S. and global), regional U.S., national and international levels. It is the largest economic consulting and forecasting company in the country. Clients include major corporations, federal, regional and local government agencies, international agencies and trade associations. DRI is a highly-quoted and closely -tracked source of economic activity, not only in the United States but throughout the world.

The DRI forecasts reflects analysis and trends for 432 sectors of economic activity, 379 of which relate to particular commodities. These are used in conjunction with a two-digit commodity / industry forecast for the State of California. This reasonably disaggregate picture of change in the states is a basis for estimating future shipment trends within and out of the state. For traffic moving into the state the forecasts reflect the projections for the shipping state.

The DRI forecasts provide a picture of the change in both production levels, and consumption levels. Earlier efforts at forecasting for the California ITMS project were limited to a production basis, with no consumption component. In addition, because the forecasts are based on total production and consumption levels, they inherently capture the impact of import and export activity.

Both the Caltrans and DRI sources were used to develop a unique set of adjustment factors for the ITMS Freight database. The county growth rates were indexed to match the state level growth rates when compiled to the more aggregate level. The commodity basis was translated to match the NAICs used in the base year data set.

The actually processing of the forecast first uses the destination or consumption data: based on the termination point of flows, by commodity, the base year volumes were adjusted in accordance with the consumption factors. The resulting flows where then adjusted based on the origin point and commodity, with a new factor developed by comparing the results after applying the destination-based forecast with the original origin growth data.

The use of specific consumption factors for ITMS version 3 represents an advancement in the forecasting technique that was used for preparing projections for previous versions of the ITMS. However, the forecasting capabilities still do not incorporate explicit modal shifts, although the modal share in the forecast are altered as a result of commodity composition and origin / destination relationships which change a differential rates.

8. DATABASE ADDITIONS

This section describes three other modifications to the commercially available TRANSEARCH database that are included in the ITMS Freight Database:

- Trailer Equivalents
- Import / Export Flags
- Freight Routing.

The freight routing assignments are described further in Chapter 6 on the Freight Flow Processor.

8.1 Trailer Equivalents

The California Freight Traffic Database has been processed to convert tons by commodity to trailer equivalents for use as a shipment unit measure of activity. A table of shipment weights by commodity is employed in the process. This table is created from information gathered through our Motor Carrier Data Exchange Program.

8.2 Import/Export Flags

The domestic portion of the import and export movements is in TRANSEARCH but is commingled with the domestic traffic. A special run of PIERS data provided the key to identifying inland origins and destinations. It did not, however, identify the mode of transportation.

For PIERS records that covered movements inside the state of California, a comparison was made with TRANSEARCH records for the same origin / destination / commodity / volume combinations. Where there were matches, the records were identified as international traffic. A second iteration was made increasing the capture volume of the TRANSEARCH records. Where there were hits, the records have been split into domestic and international portions.

Out of state, the prospect was much stronger for rail, particularly intermodal activity. Again, an effort was made to match records and then identify those records which were the same. The remaining records were compared against TRANSEARCH volumes in broad, multi-state port regional areas. Commodities were compared to the FAK (freight all kinds) intermodal records. Finally, any remaining unmatched records were entered directly into the database.

8.3 Freight Routing

Highway routing assignments are made using a least-impedance algorithm. For each origin node to destination node flow, a routing is assigned over the routing path with the lowest impedance. The impedance is a measure of desirability for each link in the network. This measure attempts to quantify a variety of factors that contribute to a truck selecting a particular route. Additionally, actual truck count data at various key points on the network is used to provide further calibration of the impedance. Rail routings were developed in a similar manner.

Four alternative routing assignments are provided for each freight flow and both highway and rail modes. These assignments are stored in a separate set of freight files called "connect files." These files and the development of route assignments are described further in Chapter 6 (Demand Models) in the discussion on the Freight Flow Processor.

A simple network of four nodes, with each node only connecting with two of the other nodes can be used as an example to illustrate the principal of the least-impedance algorithm:

Node A connects to Node B with impedance value of 10
Node A connects to Node C with impedance value of 20
Node B connects to Node D with impedance value of 40
Node C connects to Node D with impedance value of 20

Determination of the least-path from Node A to Node D will be used as an example. Starting with the network node that corresponds to the assigned origin point of a shipment, a comparison is made of the impedance values for each link that starts at the origin node. The terminating node on the link with the lowest impedance value is then considered the “closest” node.

The origin node, node A connects to both node B and node C. The impedance to node B is 10, and the impedance to node C is 20. Node B becomes the “closest” node.

A comparison is then made of the links which connect to the “closest” node, excluding “backward” links, or the link that connects back to the initial origin point. In our example, node B connects to node D, with impedance of 40. So from the origin, total impedances to the nodes tested so far are:

Node B – 10
Node C – 20
Node D – 50

These impedances are then compared, with Node C now being the “closest” node. For processing purposes Node B is no longer considered the “closest” node because all possible paths from the origin node A have been accounted for.

The process is then repeated, from the “closest” link, which is now Node C. Node C has one additional link, to Node D, with an impedance of 20. This gives a total imedance from the origin to Node D, over the path through Node C, of 40.

The patch from origin to Node D, using the links through Node C, is selected as the assigned route for this node pair, because the total impedance between the pairs is lower than the route the uses the links through Node B.

9. ITMS FREIGHT DATABASE

The ITMS Freight Database combines the information described in the previous sections. The database is composed of four files that represent enhanced versions of the TRANSEARCH database (also called California TRANSEARCH database). A separate file is provided for each of the forecast years: 1996, 2006, 2016, and 2026.

Each file contains information on the origin, destination, and total tons moved for each commodity type. Additional information is provided on truck equivalents and freight costs. Every record represents a separate origin-destination-commodity flow. Each file contains over 700,000 origin-destination-commodity records. Exhibit 3-5 provides a data dictionary for the information provided in each enhanced TRANSEARCH file.

The freight costs vary by mode and alternative routing. The ITMS freight database includes four alternative routings for both highway and rail freight movements. These routings are stored in a separate set of freight files called "connect files." A set of eight connect files (one for each year and each mode) are included in the ITMS freight database. These files are accessed by the Freight Flow Processor (described in Chapter 6) to determine the appropriate routing for each origin-destination-commodity flow for each action or strategy being tested in the ITMS. The enhanced TRANSEARCH files are linked to the connect files using the JoinCode field. A data dictionary is provided for the connect files in Chapter 6 of the Basic Documentation.

Exhibit 3-5
Data Dictionary for Enhanced TRANSEARCH California Database

Field Name	Field Description	Typ
O_FIPS	Origin FIPS Field	Numeric
O_BEA	Origin BEA Field	Numeric
D_FIPS	Destination FIPS Field	Numeric
D_BEA	Destination BEA Field	Numeric
NAICS	NAICS Commodity Code (6-digit Code)	Numeric
Rail_Ann_Tons	Rail Annual Tons	Numeric
IMX_Ann_Tons	Intermodal Container Annual Tons	Numeric
FHT_Ann_Tons	For-Hire Truckload Annual Tons	Numeric
FHLTL_Ann_Tons	For-Hire Less-Than-Truckload Annual Tons	Numeric
PrivTrk_Ann_Tons	Private Truck Annual Tons	Numeric
Air_Ann_Tons	Air Cargo Annual Tons	Numeric
H2O_Ann_Tons	Water Annual Tons	Numeric
Tot_Ann_Tons	Total Annual Tons	Numeric
Est_Trk_Cnt	Estimated Truck Count	Numeric
Truck_Eq	Total OD Pair Annual Truck (in 40-Foot Container Equivalents or FCEs) Equivalents, if all tons were shipped by truck.	Numeric
Onode	Origin Node in the Reebie California Network	Numeric
Dnode	Destination Node in the Reebie California Network	Numeric
ImpExpFlag	Import/Export Flag (0=Domestic, 1=Import, 2=Export)	Numeric
JoinCode	Join Code to Link the TRANSEARCH California Database OD Pairs to the Reebie Route Network	Alpha
FIPSCode	FIPS Code in the in "[O_FIPS]_[D_FIPS]" format	Alpha
TruckMiles	Miles that Trucks Must Travel Between Origin and Destination	Numeric
RailMiles	Miles that Rail Must Travel Between Origin and Destination	Numeric
TruckCost	Cost to Ship One Ton of Commodity from Origin to Destination by Truck on Primary Routing	Numeric
RailCost	Cost to Ship One Ton of Commodity from Origin to Destination by Rail on Primary Routing	Numeric
IMXCost	Cost to Ship One Ton of Commodity from Origin to Destination by Intermodal (i.e., Rail mode)	Numeric
TruckCost2	Cost to Ship One Ton of Commodity from Origin to Destination by Truck on Alternative 2 Routing	Numeric
TruckCost3	Cost to Ship One Ton of Commodity from Origin to Destination by Truck on Alternative 3 Routing	Numeric
TruckCost4	Cost to Ship One Ton of Commodity from Origin to Destination by Truck on Alternative 4 Routing	Numeric
RailCost2	Cost to Ship One Ton of Commodity from Origin to Destination by Rail on Alternative 2 Routing	Numeric

RailCost3	Cost to Ship One Ton of Commodity from Origin to Destination by Rail on Alternative 3 Routing	Numeric
RailCost4	Cost to Ship One Ton of Commodity from Origin to Destination by Rail on Alternative 4 Routing	Numeric

4. INTERMODAL FACILITIES

The ITMS facility data can be divided into passenger and freight data. The general approach for all facilities consisted of the following steps:

- Defining database elements matrix for target key inputs for facility attribute data tables
- Identifying specific list of facilities to include in ITMS
- Collecting facility data primarily through individually tailored questionnaires (face to face and by mail)
- Caltrans Districts and Programs provided input on facilities which facilities to include
- Following up data collection with individual properties, and industry sources
- Coding data by facility type onto spreadsheet format
- Importing data into ITMS.

Since the last two steps in this approach were identical for all facilities, the remainder of this part of the documentation focuses primarily on the questionnaire structure and the data collection sources and procedure. A sample questionnaire is provided in Exhibit 1 at the end of this section.

1. PASSENGER DATA

Facilities targeted for passenger data collection included airports, cruise terminals, and intermodal transit stations.

Although data questionnaires were tailored to meet unique characteristics at the different types of facilities, each followed a basic structure. Major sections addressed supply data: identification, classification and demand data (e.g., facility use). A complete listing of the questionnaires developed for this project is included in Exhibit 7-1, at the end of this chapter.

1.1 Airports

The airports selected for ITMS data collection consisted of the larger facilities in the State where commercial service is the primary function. These included:

Airport	City
Burbank-Glendale-Pasadena Airport	Burbank
Fresno-Yosemite International Airport	Fresno
John Wayne Airport – Orange County	Santa Ana
Long Beach Airport	Long Beach
Los Angeles International Airport	Los Angeles
Metropolitan Oakland International Airport	Oakland
Monterey Peninsula Airport	Monterey
Ontario International Airport	Ontario
Palm Springs Regional Airport	Palm Springs
San Diego International Airport	San Diego
San Jose International Airport	San Jose
San Francisco International Airport	San Francisco
Sacramento Metropolitan Airport	Sacramento
Santa Barbara Metropolitan Airport	Santa Barbara

1.2 Cruise Terminals

Only two cruise terminal facilities were included in the survey: the Los Angeles World Cruise Center and the San Diego Cruise Center. Survey data was included in with the ports layer in the ITMS.

Cruise terminal questionnaire data was supplemented by the Worldport LA Shipping Handbook.

1.3 Intermodal Transit Stations

The project team selected four intermodal transit stations for ITMS application:

Intermodal Transit Stations
Los Angeles Union Station
San Diego Santa Fe Depot
San Francisco Embarcadero Station
San Francisco Transbay Terminal

Transit station facility data was considerably more difficult to obtain than that for other facilities, because of the absence of a significant, centralized management structure for each facility. In some cases, only system-wide data was available, not station-specific data. Finally, forecast information is made difficult by the fact that few planning documents exist. When this occurred, the project team surveyed the one or two biggest operators and estimated total facility growth based on the growth of the main facility tenants.

2. FREIGHT DATA

Facilities targeted for freight data collection included airports, seaports, intermodal freight facilities, and tanker terminals.

Freight data questionnaires were also tailored to meet the unique characteristics of the different types of facilities. Major sections addressed supply data (e.g., facility identification, geometrics, freight capacity), and demand data (e.g., for 1996 and the ITMS forecast horizon years, when available).

2.1 Airports

The ITMS freight airport list is identical to the passenger airport list. In fact, many of the geometrics are the same and the two data sets were captured via the same questionnaire.

2.2 Seaports

The ITMS facility data collection targeted ten major seaports, which comprise the vast majority of all commercial seaport activity in the State. The list included:

Seaports
Port of Benicia
Port of Humboldt
Port of Long Beach
Port of Los Angeles
Port of Oakland
Port of Richmond
Port of Sacramento
Port of San Diego
Port of San Francisco
Port of Stockton

In addition to responses from questionnaires, one additional major data source was included:

- Annual Reports 1996, 1997, 1998, Pacific Maritime Association

2.3 Intermodal Freight Facilities

The project team selected a representative sample of intermodal freight facilities from the two major railroads in California: the Burlington Northern & Santa Fe (BNSF) and the Union Pacific (UP). The facilities included:

Major Intermodal Freight Facilities
City of Industry (UP)
East Los Angeles (UP)
Fresno (UP)
Lathrop (UP)
Long Beach (UP)
Los Angeles Transportation Center (UP)
Los Angeles Hobart Yard (BNSF)
Oakland (UP)
Modesto (BNSF)
Richmond (BNSF)
San Bernardino (BNSF)

The Roseville and Bakersfield facilties are closed. The project team was unable to collect data for Long Beach, Oakland, and the L A Transportation Center due to lack of response from the railroads. Public domain information for this type of data is scarce.

2.4 Tanker Terminals

Information on specific tanker terminals was obtained from the Santa Fe Pacific pipeline company (for petroleum product pipelines) and from Chevron Oil Company for their intermodal pipeline/tank farm facility in Richmond. The project team obtained information on the characteristics of the pipelines entering the facility, facility storage capacity, and the mode of transportation used to ship the product out of the terminal.

Exhibit 4-1 Sample Questionnaire for Intermodal Facilties

SEAPORT

GENERAL INFORMATION: The base year for the study is 1996. Forecast (horizon) years are 2006, 2016, 2026. Please feel free to use 2000, 2010, 2020 if those years are your planning horizon	
The questions in this paper are intended for maritime freight.	
I - SUPPLY INPUTS	
Identification	
What is the facility name?	
Who owns the facility?	
Who operates the facility?	
Who is using the facility (shipping companies, railroads, trucking companies)?	
Direct-Call Liners:	
Terminal Operating Companies:	
Railroads:	
Trucking Companies:	
Who is the primary government regulator of the facility?	
Classification	
What is the functional classification for the facility?	
Combination container	
Combination break bulk	
Combination neo bulk	
Pure container	
Pure break bulk	

Pure neo bulk (steel)	
Pure neo bulk (auto)	
Pure dry bulk	
Pure liquid bulk	
Please classify the number and types of terminals by major cargo / commodity classification (**Container, Break-Bulk, Neo-Bulk, Dry-Bulk, and Liquid Bulk**) and specify the number of berths at each.	
What is the safety designation for the facility (shelter afforded)?	
Excellent, Good, Fair, Poor, or None	
Features	
Do you have what is considered an advanced traffic control system in your industry? If yes, what is it called and how does it operate? Can we obtain copies of any related documentation?	
Mode of Access	
Does freight travel to or from the facility (Yes / No) by the following modes?	
truck	
rail (direct)	
water based	
Capacity Measures - Freight	
What is the maritime freight working throughput capability for the facility per year, in: - tons - containers (CEU, TEU) or unit volume *(i.e., working throughput capability is 1,650,000 tons per year per berth, or 3,300,000 total.)* Use the cargo / commodity classification if more appropriate.	
How do you determine freight capacity? (is it from berthing limitation, storage, the capability to transfer freight inland, or some other measure)	
What is the limiting factor on your capacity?	

Do you have a conversion factor to transform annual capability to hourly?	
What is the maximum freight the facility has handled in one hour, in: - tons - containers (CEU, TEU) or unit volume Use the cargo / commodity classification if more appropriate.	
Do you consider these figures close to capacity, i.e., what is the freight handling capacity for the whole port, in: - tons - containers (CEU, TEU) or unit volume Use the cargo / commodity classification if more appropriate.	
Geometrics - Facility Physical Characteristics	
What is the total facility area in acres?	
How many mainline railroad tracks enter the facility?	
What is the total seaport length of track?	
What is the total length of track for on-dock rail?	
How many channels does the facility have? (or is there a better way to qualify port) ease of access	
What is the maximum channel length?	
How many berths for freight ships does the facility have? (excluding bunkering)	
How many berths are dedicated to bunkering?	
Ship Characteristics	
What is the maximum length ship that can be handled (feet)?	
What is the maximum draft (feet)?	
What is the maximum size ship that can be handled (dead weight tonnage)?	
Or: what is the maximum ship handled today?	
What is the typical size ship that is handled (dwt)?	
What is the typical ship load one way (tons, TEU)?	
Geometrics Restrictions	
Are there any restrictions on the kinds of cargo handled?	

Are there any restrictions on the hours of operation for freight transport?	

Storage Characteristics	
Please describe total storage available for each of the following: - Containers - Break-Bulk - Neo-Bulk - Dry-Bulk - Liquid Bulk Provide a breakdown if it can be useful to add the storage up. Provide units separately if appropriate (i.e., m^2 or sqf for break- bulk total and gallons for liquid bulk) for the different cargo / commodity classifications.	
How many linear feet of storage tracks does the facility have?	
How many truck bays does the facility have?	
II - DEMAND INPUTS - FREIGHT	
Base Year - 1996	
Is there a peak time of year for freight throughput? What is the ratio of the peak month TEU (or CEU) to average month?	
Is there a peak time of day for freight throughput? If so, what is it in military time intervals?	
How high is the peak in relation to the average (for the peak time of day)	
What is the peak direction of traffic (compass reading), for landside outbound traffic?	
How much freight was handled per year for the base year, in - tons - containers (CEU, TEU) or unit volume (use the cargo / commodity classification if more appropriate)	

How much freight was handled hour, in - tons - containers (CEU, TEU) or unit volume (use the cargo / commodity classification if more appropriate)	

What is the total freight volume, or distribution, by distance traveled?	
0-200 miles	
200-400 miles	
400-600 miles	
600-800 miles	
over 800 miles	
What proportion of the freight is transferred from the ship via the following modes:	
- Truck (%)	
- Rail (%)	
How many inbound trains are there per day to the port?	
Do you have an estimate of the traffic generated per day (inbound + outbound)? - number of trucks: - number of trains: - number of automobiles:	
What proportion of total freight handled is non-maritime?	
Of the maritime traffic, what is the proportion between domestic versus international traffic?	
Can you provide a distribution of all freight handled per 2-digit STCC code?	
Do you have any forecasts for the above data? If so, please repeat sequence. If not, is the information available from another source?	
What is the forecasted freight handled for the year **2006**, in - tons - containers (CEU, TEU) or unit volume (use the cargo/commodity classification if more appropriate) Or what is the % change in forecasted volume for each cargo/commodity classification?	

What is the forecasted freight handled for the year **2016**, in - tons - containers (CEU, TEU) or unit volume (use the cargo / commodity classification if more appropriate) Or what is the % change in forecasted volume for each cargo / commodity classification?	
What is the forecasted freight handled for the year **2026**, in - tons - containers (CEU, TEU) or unit volume (use the cargo / commodity classification if more appropriate) Or what is the % change in forecasted volume for each cargo / commodity classification?	
What has been the average historic rate of growth in cargo handled, over the last 10 or 20 years?	
III - IMPROVEMENT ECONOMIC DATA	
Do you have an estimate for the average cost per accident?	
What is the hourly time cost for labor?	
What is the percent of fuel use by type:	
- diesel	
- gasoline	
- LNG or CNG	
- electric	
IV - PERFORMANCE MEASURE INPUTS	
Mobile Source Emissions	
Do you have an estimate for the total tons of pollutants generated at the facility?	
carbon monoxide (CO)	
particulates (PM10)	
hydrocarbon (HC)	
nitrous oxide (NOX)	

Accident Data	
How many accidents did you record in 1996?	
How many fatalities did you record in 1996?	
How many accidents at intermodal crossings?	
Do you have annual reports or other statistical summaries for your activities? If so may we obtain a copy?	

5. GIS AND TRANSPORTATION SYSTEM INFORMATION

This section presents a general overview of spatial data layers and discusses the process involved in the data collection and preparation of these layers for inclusion into the ITMS.

1. OVERVIEW

Spatial data layers for the ITMS application have been developed for use within ArcView, a geographic information system (GIS) software package developed by Environmental Systems Research Institute, Inc. in Redlands, California. Through ArcView, the user will be capable of accessing any data layer developed within ARC/INFO. Consequently, data layers can be developed in ARC/INFO for later use within ArcView.

Three fundamental categories of spatial data are utilized within ITMS:

1) Network modes including rail, highways, air corridors, shipping lanes, and pipelines;
2) Intermodal facilities including airports, ports, intermodal transfer stations, tanker terminals; and
3) Boundary layers such as counties, districts, facility boundaries, air basins.

The amount of processing required for each layer depends on availability, completeness, and additional requirements for ITMS. In general, data used within the ITMS model for which attribute data concerning freight and passengers needed to be collected were coded to identify ITMS elements.

Many sources were needed to obtain the spatial data for the ITMS. Some layers were created by hand when no good digital source was available. Exhibit 5-1, "Caltrans ITMS Spatial Data Sources," depicts all data available within the ITMS (excluding WESSEX data, local data, and other possible supplementary data sources). This exhibit specifies the master source utilized, and general information on the types of processing performed. Most layers did not require extensive processing for the ITMS and will not be discussed in this documentation. The "Comments" column of Exhibit 5-1 identifies layers requiring extensive processing, which will be detailed in Sections 2 and 3 of this chapter.

From Exhibit 5-1 it can be seen that most of the ITMS base spatial data was either obtained from the Caltrans GIS Branch or created by hand. As noted in the table, the highways and rail layers required extensive special processing and therefore have additional sections in this chapter explain the methodologies for processing these layers. For the other GIS layers itemized in the table, the methodology for ITMS processing can be described through the "Processing Notes."

Exhibit 5-1
Caltrans ITMS Data Sources

	Layer Name	Spatial Source	Processing Notes	Comments
Modal Networks	Highways	Caltrans GIS	0, 1	See Section 2
	Rail	Caltrans GIS	0, 1, 3, 4	See Section 3
	Pipelines	Hand drafted from low accuracy source	1, 2, 4	
	Air Corridors	Hand drafted	1, 2, 4	
	Shipping Lanes	Hand drafted	1, 2, 4	
Intermodal Facilities	Airports	Caltrans GIS	0, 1, 3	
	Ports	Caltrans GIS	0, 1	
	Rail Stations- Passenger	Caltrans GIS	0, 1	
	Rail Stations- Freight	Created from WESSEX Coordinates Data	1, 2, 4	
	Tanker Terminals	Hand drafted from low accuracy source	1, 2, 4	
Boundary Layers	County	Caltrans GIS	1	
	MPO	Caltrans GIS	1	
	RTPA	Caltrans GIS	1	
	Air basins	Caltrans GIS	1	
	District	Caltrans GIS	1	

	State outline	Caltrans GIS	1	
	Urban areas	Caltrans GIS	1	
	Port boundary	Caltrans GIS	1	
	BEA	Caltrans GIS	1	
	ITMS Corridor	Hand drafted	1, 2	
	TMA	Caltrans GIS	1	
Other GIS Data	Access Routes	Caltrans GIS	1	

Processing Notes:
0: Elements coded as ITMS related within Caltrans master file
1: Coordinate system to Latitude / Longitude
2: ITMS elements determined and digitized by project team
3: Attribute coded as freight / passenger
4: Other attribute codes

Spatial data was extracted from various sources including: Caltrans, Teale Data Center, Environmental Protection Agency (EPA), Federal Aviation Administration (FAA), Federal Highway Administration (FHWA), Federal Transit Administration (FTA), United States Geological Survey (USGS), National Oceanic and Atmospheric Agency (NOAA), Army Corps of Engineers, local planning agencies and MPOs, and others. Data was loaded and reviewed for completeness and available database attributes. During the search, the project team identified specific database needs and limitations to Caltrans GIS Service Center. This occurred for both the internal Caltrans sources and external sources. In response, the Caltrans GIS Branch prioritized the development of certain data layers allowing the ITMS to rely more upon internal data sources.

Layers developed in-house by Caltrans over the course of the ITMS project include:

- Ports
- Passenger Rail Stations
- RTPAs
- Port Boundaries
- BEAs

Layers improved by Caltrans GIS to meet ITMS needs during the course of the project include:

- MPOs
- Urban Areas
- Rail
- Airports

Layers primarily utilized as available within Caltrans include:

- Highways
- State Roads
- Counties
- Districts
- TMAs
- State Outline
- Air Basins

Layers that did not exist in a form complete enough for use within ITMS and therefore created by the project team include:

- Air Corridors
- Shipping Lanes
- Freight Passenger Rail Stations
- Pipelines
- Tanker Terminals

Due to the large data collection effort required for facilities and network layers used within the modeling process, "Processing Note 0" data was collected only for selected elements. To simply display within the GIS, it was also useful to code ITMS elements to allow the application to easily display only those elements utilized within ITMS and for which auxiliary data was collected.

The spatial rail file allows the user to distinguish a variety of modes in the ITMS through a series of fields identifying if the segment is used for freight, passenger rail and / or intercity rail (Amtrak). If the segment is a valid route the field is coded 1. For example, when the user selects the “Freight Rail” mode in the ITMS. The ITMS queries all records containing codes 1 in Freight field. Likewise, when “Amtrak” is selected the ITMS queries the records with the Intercity field containing code 1 and a “Passenger Rail” selects the records with the field Pass_Rail containing codes 3 through 5.

Conversion to Decimal Degrees

The Caltrans Transportation System Information Program - GIS Service Center (TSIP-GSC) standard coordinate system for GIS spatial data is in meters in an ALBERS projection with specified parameters. This coordinate system is convenient for statewide data management as it preserves distance and area relationships while allowing the state to fit within a single coordinate system. An important concern in the development of the ITMS was which coordinate system (projected or unprojected) best met the needs of ITMS users at the state and local levels. ArcView does not support display of multiple coordinate system within a View; i.e., all Themes within a View must be of the same coordinate system.

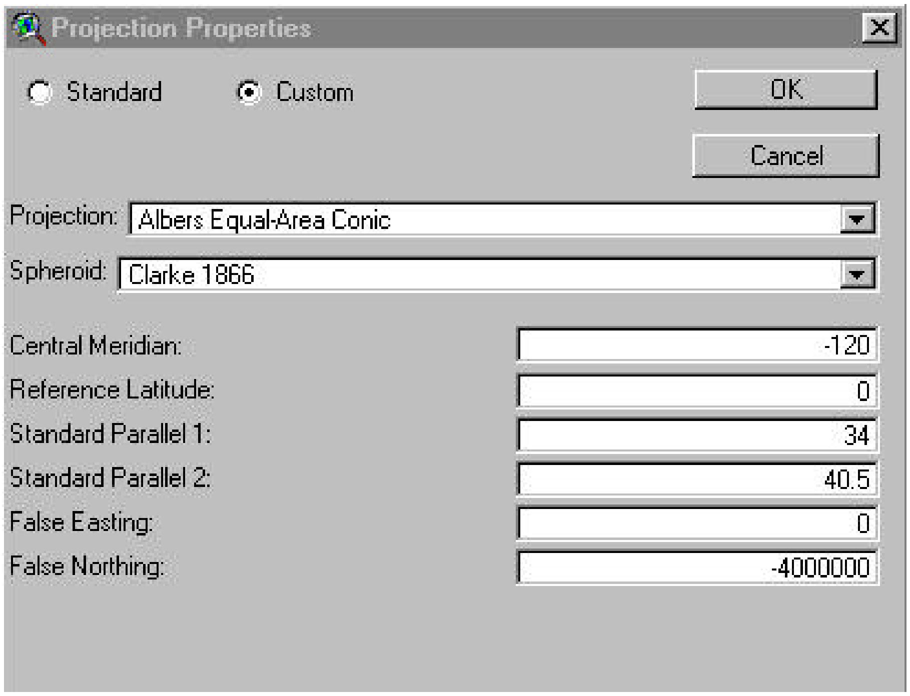
Many local governments and MPOs will have data stored within State Plane Coordinates for convenience. Other data that has been purchased for use within the ITMS is stored within the decimal degrees system (no projection but simply Latitude / Longitude) such as the WESSEX Data (distributed on multiple CD-ROMs).

Given these considerations, the project team decided to use decimal degrees coordinates system. It is a flexible system which can be easily imported by any GIS systems. Themes using decimal degrees coordinates can be also displayed in multiple projections. Another advantage of using decimal degrees is that the WESSEX data used by the ITMS would require no additional processing (or conversion from native CD-ROM) to be integrated into ITMS. This decision necessitates the conversion of all Caltrans GIS data from ALBERS into Earth Coordinates in Decimal Degrees. The conversion process was done in ArcView.

Any other spatial data that is to be utilized with the ITMS application must be converted into the following coordinate system:

- Earth Coordinate System
- Units in Decimal Degrees
- Datum NAD83.

Exhibit 5-2
ArcView Projection Conversion Tool



ITMS Elements Determined and Digitized by Project Team in ITMSv2

As noted earlier, there were several spatial data layers needed within the ITMS application for which no good digital source existed. In some cases, not even good paper sources existed that could be readily utilized for a statewide digitizing effort. For these cases, digital spatial data was created by the project team to meet the small scale mapping needs of the project. Where available, coordinates and maps were utilized to keep the accuracy close to the 1:100,000 scale accuracy found in Caltrans' GIS data.

Layers created by hand and their general characteristics include:

Layer Name	Primary Source of Coordinates	Approximate Scale
Pipelines	Pipeline company maps*	1:2,000,000
Air Corridors	Improvised for model	No relationship**
Shipping Lanes	Improvised for model	1:100,000
Rail Freight Stations	Coordinates from WESSEX Data	1:100,000
Tanker terminals	Pipeline company maps*	1:1,000,000

* Natural gas pipeline maps were received from the Pacific Gas & Electric Company. Most major petroleum product pipeline maps came from the Santa Fe Pacific Pipeline Company and from pipeline maps purchased from the PennWell Company (publishers of the Oil and Gas Journal). Partial maps were obtained from the California State Energy Commission. Pipeline segments were digitized from the maps.

** No reasonable source was used in the creation of this data. All locations and coordinates are approximate, yet sufficient for ITMS modeling.

These layers are being provided to the TSIP-GSC for storing with the Department's other spatial data. Any modifications or updates to these layers can be done at the ITMS project level or by Caltrans GIS but should in either case be coordinated with Caltrans GIS to assure that ITMS and the department have the same data for sharing.

2. HIGHWAY SPATIAL DATA SETS

While most spatial layers involved little processing in order to incorporate them into the ITMS, the highway and rail layers required extensive processing. Rail layer processing is described in Section 3 of this document.

Processing Caltrans highway spatial data and attribute data for use within the Caltrans ITMS system is a series of operations. The entire process consists of four main parts. They are:

- Data Integration and Building Model Links
- Standardizing Coordinate System
- Data Quality Control.

2.1 Highway Data Description

The process requires three types of data as input -- GIS spatial data, TASAS (Traffic Accident Surveillance and Analysis System) event data and Travel Demand Model (TDM) data. The description of data structures and data format is presented as followed.

2.1.1 GIS Spatial Data

The Caltrans District ITMS Coordinators provided segmentation limits, in postmiles to Caltrans Transportation System Information Program - GIS Service Center (TSIP-GSC). The TSIP-GSC provided the spatial data for the application, using the Caltrans dynamic segmentation postmile process.

Several fields were added to the shapefile to provide additional information regarding the segment. The Highway data dictionary provides definitions of the fields within the highway shapefile.

2.1.2 GIS Segmentation Process

The Travel Demand Model Data was the basis for the route segmentations. The data was provided in the form of spreadsheets. This data was input into the dynamic segmentation program "Arcview Postmile Process Application" to create the ITMS segments in the shape files. The travel demand model data also provides segment descriptions used select the corresponding segment on the GIS shape file.

2.2. Operational Procedure

As mentioned in Section 1, the processing can be viewed as two parts. To some degree the parts are sequential. This section will emphasize the function and the procedure of each part.

2.2.1 Travel Demand Model (TDM)/TASAS and TSN (Transportation System Network) Data Procedures

As noted in Section 1, the Caltrans District ITMS Coordinators provided the segmentation for the ITMS. This ITMS segmentation was provided to Caltrans for both collection of TASAS data and Travel Demand Model data.

2.2.2 Data Integration and Building Model Links

The spatial data is linked to the highway attribute table by GIS_ID, a unique identifier for each arc in the shape file. Thus a unique TDM segment ID or TDM-ID can be generated by combining the unique node ID for each end of the segment into a single field. The TDM-ID is attached to the GIS spatial data coverage by selecting arcs (using ArcView). Once this ID is attached to the GIS spatial coverage, the TDM data can be queried and displayed within the GIS as a related table. This ultimately creates a file with both highway attribute and TASAS geometrical data.

TASAS(TSN) data and TDM data are combined into a single table which can be related back to the highway’s coverage via GIS-ID. In addition, for ITMS modeling, on the transportation application side it is required that GIS spatial data is able to link and display associating information on transportation demand and other non-GIS spatial data.

2.2.3 Coordinate System Conversion

As we described in CONVERSION TO DECIMAL DEGREES, the projection of Caltrans' GIS coverages is ALBERS. Since many other source data such as WESSEX data and commonly local data are in the earth or Latitude/Longitude system, the GEOGRAPHIC coordinate system is considered the most universal. All GIS coverages need to be converted into GEOGRAPHIC coordinate system. The ArcView extension "Projector!" was used to implement the conversion. See Exhibit 5-2 for more details.

2.2.4 Data Quality Control

Data quality control focuses on how to guarantee data processed throughout the above procedure without major errors for use within the Caltrans ITMS project. It is a tedious but very important step. During the entire process, data errors often occur. We will illustrate data errors that we have anticipated and describe efficient ways to identify and correct these errors.

2.2.4.1 Duplicate GIS-IDs in 58 Countywide Highway Coverages

If Caltrans maintains GIS coverages properly, the GIS-ID in GIS coverages should be unique. It is a significant item for linking other source data back to GIS spatial data in intermediate processes. To check duplicate GIS-IDs the data files (*.dbf) SUMMARIZE command in the ArcView tables can be used to create a summary table based on a shapefile table. If the "COUNT" of records in the summary table is equal to one, statistically speaking there is a good probability that no duplicate GIS-IDs existed in the coverage. **Note: Duplicates only occur in the case of bypass routes where the base year route is geographically different than it is in the forecasted years.**

When duplicate GIS-IDs exist, they need to be assessed. There can only be one GIS_ID for each of the forecast years.

3. RAIL SPATIAL/ATTRIBUTE SETS

This section describes the procedures for applying the GIS-ID code to the rail spatial layer and dissolving the layer. The GIS-ID is used by the ITMS tool to join the spatial attribute table to the data tables containing the rail geometric and demand data for both passenger service and rail freight.

Unlike the highway layer, the ITMS rail layer was developed in a different manner. This process was performed in ESRI's ArcView and incorporated a variety of manual procedures involving the following steps:

1. Convert spatial data to decimal degrees
2. Assign GIS-ID codes and dissolve state-wide rail layer
3. Attach GIS-ID codes to geometric and demand data tables.

3.1 Convert Spatial Data To Decimal Degrees

As discussed in the *Projection to Latitude/Longitude* section all spatial layers must be converted into decimal degrees for use in the ITMS. This conversion was performed by the project team using the "Projector!" extension in ArcView.

3.2 Apply Rail_id Code

The subset layers needed by the ITMS to display and model particular modes (e.g., Amtrak, Freight Rail, Passenger Rail) was created using the rail layer. A unique set of Rail_id codes were developed and placed in the “Rail_id” field of the rail spatial attribute table (“ITMS_RAIL.DBF”).

3.3 Apply Itms_id Code

This code identifies the highway segment that competes against the corresponding rail segment. This is used for the Mode Sift Model. The ITMS_id code is placed in the “ITMS_id” field of the rail spatial attribute table (“ITMS_RAIL.DBF”).

3.4 Dissolving the Rail Layer

The rail layer was dissolved in order to reduce the number of segments. The data for the rail layer was in station to station format. This layer was aggregated based on criteria that included station locations, tunnel height, maximum weight, and county lines.

4. GEOMETRICS

This section covers the geometric data documentation for pipelines, freight rail, highways, and shipping lanes.

4.1 Pipelines

The project team sought to obtain a representative sample of the major pipelines with intermodal significance, which included:

- Crude oil pipelines
- Petroleum product pipelines
- Natural gas pipelines

Key pipeline features researched included pipe alignment, diameter and capacity. Contact with oil companies, railroad pipeline companies, and natural gas suppliers was met with varying degrees of cooperation. While most companies expressed a willingness to cooperate, not all followed through. The project team was successful in obtaining maps containing pipeline alignments, as well as the complete state maps for the entire natural gas system from the Pacific Gas and Electric Company. The team also received a set of maps providing alignments for most of the major petroleum product pipelines from the Santa Fe Pacific Pipeline Company, and partial maps of pipelines from the California State Energy Commission. In addition, the decision was made to purchase a detailed set of pipeline maps of California published by PennWell Company (publishers of the Oil and Gas Journal).

4.2 Freight Rail

The project team used a variety of sources to obtain railroad geometric information including conversations with railroad executives, officials from Caltrans, the California Public Utility Commission, and Federal Railroad Administration. Some of the items on the original project team "wish list" were difficult to obtain due in part to the private nature of rail transportation and the lack of substantial data currently in database form.

The most authoritative sources of information are the railroads' track charts and timetables. Caltrans Rail Division had copies of the track charts for the two major railroads:

- Burlington Northern & Santa Fe

- Union Pacific.

From the track charts, it was possible to extract the specific alignments, mileposts, stations, number of tracks, maximum train speeds, the degree of curves in the alignment, and location of pipelines in the right-of-way. Height and clearance restrictions were obtained from the Association of American Railroads' publication Railway Line Clearances, Association of American Railroads (published annually by K-III Directory Corporation, New York, NY).

4.3 Highways

Caltrans District Coordinators chose the highways in their districts to be include in the current version of the ITMS. Coordinators were also responsible for selecting the segmentation.

Highway geometrics and the TASAS manipulation process are discussed in detail in the section of this chapter on Spatial Coverages.

The Highway Attribute data can be broken down into five types:

Relational Data: Fields used to related data to highway shape file, fields used to access freight data used in the freight flow processor, fields used to join data collected from multiple sources (Travel Demand Model data, Caltrans Transportation System Network (TSN) into one table.

GIS_ID	JOINHWYS_A	JOINHWYS_B
1		
2		
3	1455_1456	1456_1455
4	1455_1456	1456_1455
5	1455_1456	1456_1455
6	2330_2305	2305_2330
7		
8	2330_2305	2305_2330
9	2330_2305	2305_2330
10	2330_2305	2305_2330
11	2325_1485	1485_2325

Highway System Designations: Fields describe different highway system designations. This data was provided from Caltrans Functional Classification GIS data, it includes, Federal Functional Classification (Fedfunc), Interregional Road System (IRRS), National Highway System (NHS), Strahnet, Freeway and Expressway System (F_E), and Bicycle Access.

FEDFUNC	NHS	SCENIC	STRAHNET	F_E	IRRS	BIKE
6	0	1	0	0	1	1
6	0	1	0	0	1	1
2	5	1	0	2	1	1
0	0	0	0	0	0	1
2	5	1	0	2	1	1
2	5	1	0	2	1	1
2	5	1	0	2	1	1
6	0	1	0	2	1	1
6	0	1	0	2	1	1

TASAS data used within the ITMS not only to provide broad segment accident information but also provided information that describes the Highway Network. This includes, but is not limited to, highway accident, lane designations such as bus lane, toll road, forest road. Please refer to the data dictionary source column for additional information for the sources for specific fields.

TERR_TYPE	TOLL_RD	FOREST_RD	L_BUS_LN	R_BUS_LN
M	F	T	F	F
M	F	F	F	F
M	F	T	F	F
M	F	F	F	F
M	F	F	F	F
M	F	F	F	F
M	F	F	F	F
M	F	F	F	F
R	F	F	F	F
R	F	T	F	F
M	F	T	F	F

Travel Demand Model data: The Regional Models were the source of data for these fields. In the case where the region does not have a travel model, the District provided the data. This includes, but is not limited to, number of lanes, lane capacities, peak hour and daily volumes, speeds, and average vehicle occupancies (directional). An appendix provides detailed information regarding specific person movement data by county.

F_A_LANES	F_B_LANES	F_A_HOV_LN	F_B_HOV_LN	C_A_FFSPD	C_B_FFSPD	C_A_VPHPL
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
1	1	0	0	50	50	700
2	2	0	0	40	40	700
2	2	0	0	45	45	700
1	1	0	0	45	45	700
1	1	0	0	50	50	700

The fifth type of data is Freight data. This provides segment information regarding the tonnage of certain freight categories. For more information regarding freight data, please refer to the Freight section of the Basic Documentation.

A_totton	A_imx	A_fh_trk	A_fh_ltl	A_prtrk	A_naic111	A_naic112
1202646	60880	759841	71743	243595	289955	10141
1202646	60880	759841	71743	243595	289955	10141
2024764	60880	1387029	72398	437869	714879	66197
1441289	0	1367572	0	73717	1365987	
622349	0	584376	0	37973	583534	
622349	0	584376	0	37973	583534	
622349	0	584376	0	37973	583534	
622349	0	584376	0	37973	583534	
99324	0	74183	77	25063	69316	1143
99324	0	74183	77	25063	69316	1143
3346489	0	2853523	1436	491526	2165405	1512
1943053	70506	654154	96084	67412	11767	23
1943053	70506	654154	96084	67412	11767	23
1943053	70506	654154	96084	67412	11767	23
1943053	70506	654154	96084	67412	11767	23
1943053	70506	654154	96084	67412	11767	23
4787770	70506	3486795	88938	558779	2165530	1528
4839111	70506	3533264	88938	563651	2211724	1528

4.4 Shipping Lanes

The first step in determining waterway geometrics consisted of identifying significant waterway channels. In this case, significant waterway channels are defined as those navigable channels connecting the ITMS ports to the main coastal waterway.

The ITMS seaport list included ten California seaports: Humboldt Bay, Sacramento, Benicia, Richmond, Stockton, Oakland, San Francisco, Long Beach, Los Angeles, and San Diego. Of this list, only Sacramento is located deep inland, on the Sacramento river. Four of the ports (Richmond, Benicia, San Francisco, and Oakland) can only be reached once the ships pass through the narrow entrance to San Francisco Bay.

The project team obtained channel depths (at mean lower low tide) and widths at the narrowest points. Also collected were bridge clearances for each channel or waterway segment providing: name of bridge structure, height above sea level, and bridge width. These key waterway statistics are presented in Exhibit 5-3.

Exhibit 5-3
Waterway Geometrics

Channel	Channel Geometrics		Bridge Clearances		
	Depth (ft)	Span (ft)	Bridge Name	Bridge Height (ft)	Bridge Span (ft)
Golden Gate Strait	100	4,000	Golden Gate Bridge	211	4028
San Francisco Main Ship Channel	55	2,000	NA	NA	NA
Oakland Outer Harbor Channel	35	800	NA	NA	NA
Richmond Main Ship Channel	45	600	San Rafael Bridge	135	970
San Pablo Strait	43	2,000	NA	NA	NA
Carquinez Strait	45	600	Carquinez Bridge	134	998
Suisun Bay	33	350	NA	NA	NA
Sacramento River Deep Water Channel	30	300	Rio Vista Bridge	125	270
San Joaquin-Stockton Deep Water Channel	30	400	Antioch Bridge	135	400
Humboldt Bay Entrance Channel	40	500	NA	NA	NA
Los Angeles Harbor Entrance Channel	42	700	Vincent Thomas Bridge	65	1150
Long Beach Channel	60	700	Ocean Blvd. Bridge	155	300
San Diego Harbor Entrance Channel	42	800	Coronado Bridge	195	600

Waterway geometric data were obtained from two primary sources:

- Nautical Charts (various), National Oceanic and Atmospheric Administration (NOAA)

- Port Series 27 (San Diego), 28 (Los Angeles and Long Beach), 30 (San Francisco and Humboldt Bay), 31 (Oakland, Richmond, and Carquinez) and 32 (Sacramento and Stockton), U.S. Army Corps of Engineers.

5. SAFETY

The following provides a listing of data obtained from TASAS for the ITMS. The data needs falls into three specific categories -- the facilities included in the ITMS system, the data fields required by segment for each facility, and accident data.

<u>Data Fields for Facilities</u>

The following is a list of data fields from TASAS excluding accident statistics:

- District
- Route
- County
- Functional Class TASAS
- Post Mile
- FA Route
- Toll/Forest
- Rural/Urban
- Terrain
- Posted Speed

<u>Accident Data</u>

The accident code definitions by location include:

- District
- Route
- Severity
- File Type
- Side of Highway
- Party Type
- Persons Killed
- Persons Injured.

TASAS data within ITMS included segment accident information, as well as other roadway information such as posted speeds, terrain type, various roadway designations, such as bus only lanes, elevated roadways. The data sources for the highway data is identified in the data dictionaries. Accident data was for a one-year period and collected for each ITMS segment. The data provided is a snapshot of the information for the year 1996. Please refer to the data dictionary source column for more information on the sources for specific fields. An example of ITMS fields based on TASAS data is illustrated below.

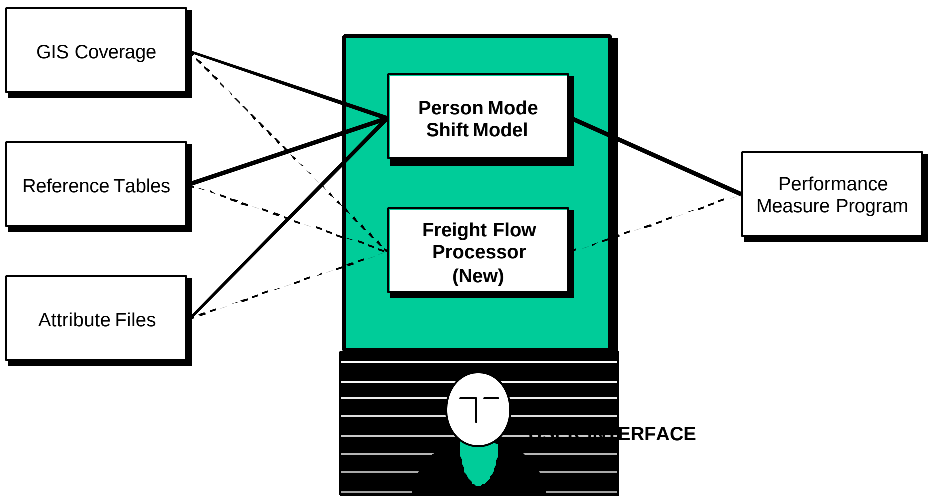
L_tot_acc	R_tot_acc	L_inj_acc	R_inj_acc	L_fat_acc	R_fat_acc
-9	-9	-9	-9	-9	-9
2	2	1	2	0	0
1	3	4	0	0	0
11	9	4	9	0	0
9	12	11	10	0	0
9	12	11	10	0	0
1	11	16	1	0	0
6	4	4	2	0	0
3	2	1	4	0	0
2	4	8	1	1	0
2	0	0	2	0	0
2	1	0	1	0	0
0	0	0	0	0	0
2	0	0	2	0	0
0	3	2	0	0	0

6. DEMAND MODELS

Although the ITMS includes information and forecasts from regional planning models, these data are static and represent a snapshot at a particular point in time. The real strength of the ITMS is the ability to evaluate proposed actions and plans using built-in analytic routines. Once the actions and strategies have been defined, the ITMS allows users to conduct what-if analyses to determine the potential impacts on the transportation system.

As illustrated in Exhibit 6-1, the core of these analytic capabilities are the demand models included within the ITMS. The ITMS contains two separate demand models. The first model – the person mode shift model – forecasts the impact of proposed actions and plans on the transportation modes that travelers choose to use. The second model – the freight flow processor – focuses on the impact of proposed actions and plans on freight. Unlike the person mode shift model, the freight flow processor considers changes in mode and routing. The freight flow processor is, in a sense, a self-contained travel demand model for goods movement. The freight flow processor is a new demand model for ITMS version 3 that was not included in previous versions.

Exhibit 6-1
ITMS Demand Models



Both models output a series of standard performance measures to show the impact of the action or strategy on the transportation system. These measures are described in detail in Chapter 7 of the Basic Documentation. The remainder of this chapter describes each of the two demand models contained in the ITMS:

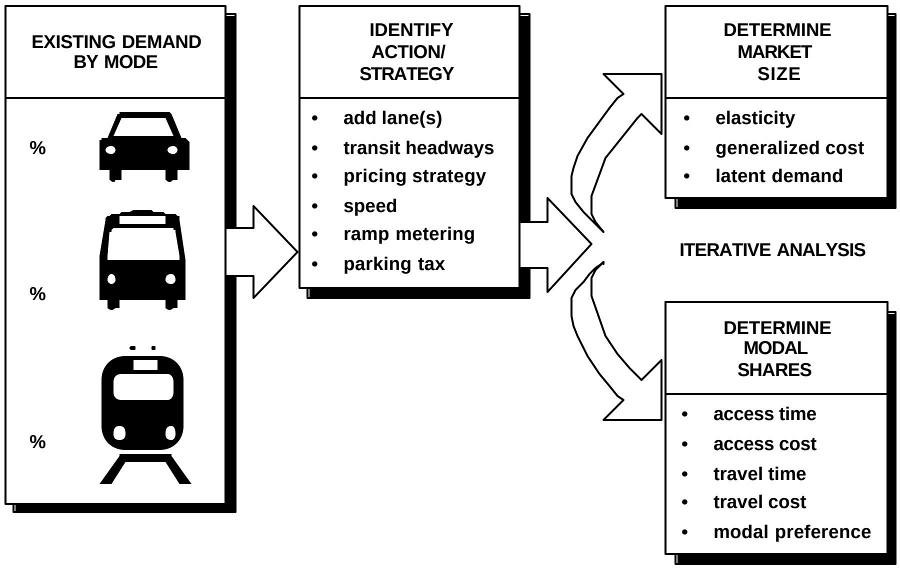
- Person Mode Shift Model
- Freight Flow Processor.

1. Person Mode Shift Model

The person mode shift model assesses the expected impact of an action or strategy on demand by mode. The person mode shift model is a macroscopic level screening tool for actions and strategies -- it is not intended to replace rigorous travel demand models. The ITMS mode shift model interacts with data and demand forecasts produced by regional travel demand models (e.g., UTPS, EMME/2, TRANPLAN, MINUTP). The intent of the model is to support planners in evaluating a wide range of alternative actions and strategies to resolve specific corridor deficiencies. Given the level of effort and expertise involved in applying regional travel demand models, in most cases it has not been possible to evaluate a wide range of options. ITMS addresses this by providing a reasonable macroscopic level of analysis that requires minimal time and expertise to apply. After narrowing the options with ITMS, a more detailed analysis of the proposed action or strategy may be necessary using a regional travel demand model.

As illustrated in Exhibit 6-2, the person mode shift model allows passengers to change modes based on their relative attractiveness given proposed actions or strategies. The person mode shift model does not forecast person travel demand. It uses the person travel demand forecasts produced by local models and incorporated into the ITMS database. Mode shifts occur in ITMS when access or travel price changes, or when access time or travel speed (time) changes.

Exhibit 6-2
Person Movement Mode Shift Model



The model focuses on modes addressed by local person travel demand models:

- Automotive travel in mixed flow lanes
- Automotive travel in HOV lanes
- Intercity bus travel
- Transit rail travel (e.g., light rail, heavy rail, commuter rail)
- Amtrak and other intercity rail travel

Passenger air traffic is not included as a competitive mode in the ITMS mode shift model, just as it is not included in regional travel demand models.

1.1 Modal Characteristics and Preferences

Each of the modes considered in the ITMS person mode shift model contains unique characteristics that need to be considered. The ITMS mode shift model recognizes that different modes of transport that exist in the same corridor are not exclusive of each other, but neither are they perfect substitutes.

The automobile mode requires the traveler to own an automobile or have a relationship to someone who owns an automobile. One of the great advantages of the automobile mode is the ability to provide easy access without delay. Automobiles also provide a high degree of trip flexibility. They can serve an almost unlimited number of origins and destinations and are available for travel at any hour. However, automobiles frequently encounter a storage cost (parking) at one or more ends of the trip.

Passenger buses provide very different amenities to their passengers, and the travel characteristics differ greatly from the automobile mode. Unlike automobiles, buses can be boarded at only specific locations (i.e., bus stops or stations). Access to passenger buses usually involves a wait time to board, and occasionally there is an access fee (e.g., parking at the system entry point). While there are some restrictions on entry (boarding) and exit (alighting) points for buses, numerous points are generally found in the bus network, particularly for local buses. Buses may offer travelers a chance to relax, read, and socialize -- features not often found in the automobile mode. However, buses usually travel at speeds below those of automobiles, since they must travel in mixed flow traffic and make stops. In some cases, particularly for express buses, bus speeds can equal or slightly exceed automobile speeds when traveling on independent right-of-ways or high occupancy vehicle lanes.

The passenger rail mode shares some travel characteristics with passenger buses. Like buses, the rail system can only be accessed at specific locations (i.e., rail stations). In addition, rail sometimes has an access fee (parking cost). Access fees due to parking costs are much more common for passenger rail, such as commuter railroads, heavy rail, and inter-city rail, than for buses. Compared to buses, rail generally has few access and egress points, and is more likely to require the use of another mode (e.g., automobiles or buses) for access. In congested regions, passenger rail frequently travels at greater speeds than either buses or automobiles. Rail often has an independent social appeal to many riders and generally offers a comfortable, quiet ride free of traffic distractions.

The mode shift model recognizes modal preferences. If the modes were perfect substitutes, any price and/or speed difference would (theoretically) shift all travelers from the highest cost/lowest speed mode of transport to the lowest cost/highest speed mode. If the modes were completely exclusive, the user could choose a price/time elasticity for each mode and change the level of demand within that mode based on cost and speed alone.

In reality, travelers are influenced by a variety of factors that complicate mode shift estimations. These factors include:

- Service characteristics for each mode
- Travel time
- The total price for travel.

Many other qualitative factors may also influence travelers' decisions to take certain modes. In addition, travelers can make choices to increase or decrease their frequency of travel.

The ITMS person mode shift model addresses these choices at a macroscopic planning level. Changes in travel time and cost can change both the modal shares of person trips and the total market size. The ITMS uses a revealed preference modal bias when analyzing shifts in demand. The revealed modal bias measures the propensity of trip makers to distribute themselves among travel modes available, even at a common price, when analyzing shifts in demand.

The modal bias provides a level basis for comparing choices between modes. The bias factor represents the propensity of a traveler to substitute one mode of travel for another, even at the same unit price and speed (price per mile or kilometer). The factor is calculated for each unique corridor segment in the state.

The modal bias accounts for modal differences in:

- Service quality
- Speed
- Frequency
- Market attractiveness
- Comfort

- Security
- All other factors not directly accounted for by price.

1.2 Mode Shift Variables

Each field marked with an asterisk affects the mode shift model calculations.

- **TRIP - Passenger Trips**, the total number of trips made on a given mode within a corridor

- **PTRIP - Proportion of Trips**, one-way person trips per time period (i.e., peak hour or daily)

- **SUMTRIP - Trips in Corridor**, sum of all competing person trips on selected segment(s) in a corridor

- **LAT - Latent Demand***, percentage growth in trips unrelated to cost and time changes

- **AP- Access Price***, the access or terminal cost of trips made. This value is divided by 10 miles in the model for urban trips and 20 miles for rural trips, which represents the average 24-hour person trip made using the freeway system in California.

- **TP - Travel Price***, price per mile traveled, excluding the terminal cost

- **AT - Access Time***, the time required to connect with the mode of travel (sometimes called wait time), expressed in fractions of an hour

- **TT - Travel Time**, the time spent in transit on the mode of choice (calculated using speed and distance traveled)

- **WAGE - Travel Time Price per Hour**, the hourly labor value of travel time costs

- **MPH - Speed**, stated in miles per hour

- **FFSPD - Free Flow Speed***, the uncongested speed

- **V/C - Volume/Capacity Ratio**, which is the same as demand divided by (lanes times capacity per lane)

- **DIST - Length**, the length of the link traveled

- **AVEDIST - Average Distance**, the average length of a trip using the ITMS network

- **LANES***, the number of lanes

- **CAP - Capacity***, the lane capacity

- **GP - Generalized Price**, the result of access and travel costs and time costs per mile traveled

- **AVEGP - Average Generalized Price**, across all competing modes in a corridor

- **E - Elasticity**, measured as point elasticity or shrinkage ratio (percent change in trips divided by percent change in price)

- **K - Modal Bias Factor**, a measure of the propensity of travelers to distribute themselves among modes even at a common price

- **p - Peak/Daily**, indicates the time period of data

1.3 Mode Shift Equations

The mode shift model calculations are straightforward and apply to any number of modes.

<u>STEP 1</u>: Determine Generalized Price per Mile by Mode (peak and daily)

$GP1_a =$ $((AP1_a / AVEDIST) + (TP1_a)) + (((AT1_a / AVEDIST) + (60min / MPH1_a)) * (WAGE / 60min))$

$GP1_b =$ $((AP1_b / AVEDIST) + (TP1_b)) + (((AT1_b / AVEDIST) + (60min / MPH1_b)) * (WAGE / 60min))$

... ...

$GP1_n =$ $((AP1_n / AVEDIST) + (TP1_n)) + (((AT1_n / AVEDIST) + (60min / MPH1_n)) * (WAGE / 60min))$

<u>STEP 2</u>: Determine Proportion of Person Trips by Mode

$PTRIP1_a =$ $TRIP1_a / (TRIP1_a + TRIP1_b + ... + TRIP1_n)$

$PTRIP1_b =$ $TRIP1_b / (TRIP1_a + TRIP1_b + ... + TRIP1_n)$

... ...

$PTRIP1_n =$ $TRIP1_n / (TRIP1_a + TRIP1_b + ... + TRIP1_n)$

STEP3: **Determine Total Competing Person Trips in Corridor**

Peak = $(PEAKTRIP1_a + PEAKTRIP1_b + ... + PEAKTRIP1_n)$

Daily = $(DAILYTRIP1_a + DAILYTRIP1_b + ... + DAILYTRIP1_n)$

STEP 4: **Calculate K Factors (i.e., modal preference factors)**

K_{ab}= $(PTRIP1_b / PTRIP1_a) * (GP1_b / GP1_a)$
K_{ac}= $(PTRIP1_c / PTRIP1_a) * (GP1_c / GP1_a)$
... ...
K_{an} $(PTRIP1_n / PTRIP1_a) * (GP1_n / GP1_a)$
... ...
K_{n-1n}= $(PTRIP1_n / PTRIP_{1n-1}) * (GP1_n / GP1_{n-1})$

STEP 5: **Calculate the Weighted Average Generalized Price per Mile Across All Modes in the Corridor**

AVEGP1= $(GP1_a * PTRIP1_a) + (GP1_b * PTRIP1_b) + ... + (GP1_n * PTRIP1_n)$

STEP 6A: **Calculate Future Generalized Price per Mile for Each Competing Mode in the Corridor**

$GP2_a$= $((AP2_a / AVEDIST) + (TP2_a)) + (((AT2_a / AVEDIST) + (60min / MPH2_a)) * (WAGE / 60min))$

$GP2_b$= $((AP2_b / AVEDIST) + (TP2_b)) + (((AT2_b / AVEDIST) + (60min / MPH2_b)) * (WAGE / 60min))$
... ...
$GP2_n$= $((AP2_n / AVEDIST) + (TP2_n)) + (((AT2_n / AVEDIST) + (60min / MPH2_n)) * (WAGE / 60min))$

STEP 6B: **Calculate Future Generalized Price per Mile Across Competing Modes**

AVEGP2= $(GP2_a * PTRIP2_a) + (GP2_b * PTRIP2_b) + ... + (GP2_n * PTRIP2_n)$

STEP 7: **Estimate the New Total Passenger Trips for the Corridor Segment(s)**

SUMTRIP2= (SUMTRIP1 * (E * ((AVEGP2 - AVEGP1) / AVEGP1) + 1))

STEP 8: **Solve for New Passenger Trip Ratios**

ratios n Choose 2: $PTRIP2_b / PTRIP2_a = K_{ab} * (GP2_a / GP2_b)$
$PTRIP2_c / PTRIP2_a = K_{ac} * (GP2_a / GP2_c)$

...

$PTRIP2_n / PTRIP2_a = K_{an} * (GP2_a / GP2_n)$

$PTRIP2_n / PTRIP2_{n-1} = K_{n-1n} * (GP2_{n-1} / GP2_n)$ -These can also be inverted

STEP 9: Solve for New Passenger Trips by Mode Using the New Passenger Trip Ratios

new trips	n new trips using <n Choose 2> Ratios
$TRIP2_a=$	$SUMTRIP2 / ((1 + (PTRIP2_b / PTRIP2_a) + (PTRIP2_c / PTRIP2_a) + ... + (PTRIP2_n / PTRIP2_a))$
$TRIP2_b=$	$SUMTRIP2 / ((1 + (PTRIP2_a / PTRIP2_b) + (PTRIP2_c / PTRIP2_b) + ... + (PTRIP2_n / PTRIP2_b))$
$TRIP2_n=$	$SUMTRIP2 / ((1 + (PTRIP2_a / PTRIP2_n) + (PTRIP2_b / PTRIP2_n) + ... + (PTRIP2_n / PTRIP2_n))$

STEP 10A: Calculate New Passenger Trip Proportions

$PTRIP2_a=$	$TRIP2_a / (TRIP2_a + TRIP2_b + ... + TRIP2_n)$
$PTRIP2_b=$	$TRIP2_b / (TRIP2_a + TRIP2_b + ... + TRIP2_n)$
...	...
$PTRIP2_n=$	$TRIP2_n / (TRIP2_a + TRIP2_b + ... + TRIP2_n)$

STEP 10B: Calculate the Change in Travel Speeds by Mode

Auto:

$MPH3_a = FFSPD / (1+.15* (((TRIP2_a / AVO_a) / (LANES_a * CAP_a))^4))$

$MPH3_b = FFSPD / (1+.15* (((TRIP2_b / AVO_b) / (LANES_b * CAP_b))^4))$

...

$MPH3_n = FFSPD / (1+.15* (((TRIP2_n / AVO_n) / (LANES_n * CAP_n))^4))$

Bus: Use the values of Auto

Rail:

$MPH3_a = FFSPD$

$MPH3_b = FFSPD$

...

$MPH3_n = FFSPD$

STEP 10C: Calculate New Generalized Price

$GP3_a = ((AP2_a / AVEDIST) + (TP2_a)) + (((AT2_a / AVEDIST) + (60min / MPH3_a)) * (WAGE / 60min))$

$GP3_b = ((AP2_b / AVEDIST) + (TP2_b)) + (((AT2_b / AVEDIST) + (60min / MPH3_b)) * (WAGE / 60min))$

$GP3_n = ((AP2_n / AVEDIST) + (TP2_n)) + (((AT2_n / AVEDIST) + (60min / MPH3_n)) * (WAGE / 60min))$

STEP 11: Recompute New Average Generalized Price Using New Passenger Trip Proportions

AVEGP3= $(GP3_a * PTRIP2_a) + (GP3_b * PTRIP2_b) + ... + (GP3_n * PTRIP2_n)$

STEP 12: Estimate Next Iteration of the New Total Passenger Trips for the Corridor Segment(s)

SUMTRIP3= (SUMTRIP1* (E * ((AVEGP3 - AVEGP1) / AVEGP1) + 1))

STEP 13: Solve for New Passenger Trip Distributions by Mode

new trips n new trips using <n Choose 2> Ratios

$TRIP3_a$= $SUMTRIP3 / ((1 + (PTRIP2_b / PTRIP2_a) + (PTRIP2_c / PTRIP2_a) + ... + (PTRIP2_n / PTRIP2_a))$

$TRIP3_b$= $SUMTRIP3 / ((1 + (PTRIP2_a / PTRIP2_b) + (PTRIP2_c / PTRIP2_b) + ... + (PTRIP2_n / PTRIP2_b))$

... ...

$TRIP3_n$= $SUMTRIP3 / ((1 + (PTRIP2_a / PTRIP2_n) + (PTRIP2_b / PTRIP2_n) + ... + (PTRIP2_{n-1} / PTRIP2_n))$

1.4 Model Operation

As illustrated in Exhibit 6-3, the person mode shift module combines Avenue and C+++ routines.

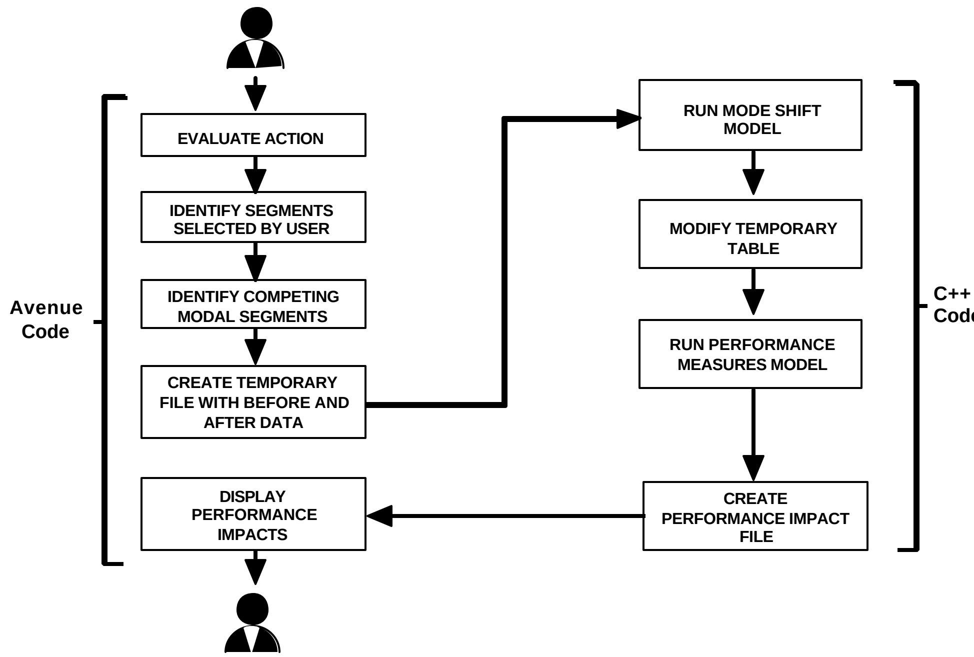
The person mode shift model begins by selecting the competing segments for different modes in the corridor. Each modal segment record includes a field that identifies competing segments for different modes of person travel (data contained in I_SEG_ID). The ITMS creates a temporary file with all the data attributes of competing segments across all passenger modes for the action or strategy selected for evaluation.

The temporary file is passed to the C++ programs, starting with the person mode shift model. The person mode shift model performs its analysis using the temporary files and changes the demand values by mode based on results. The revised temporary file is then passed to the performance measurement C++ programs, and an output file is created with all results. The ITMS displays this output file once all analysis is complete.

The AFS is not redefined as a result of this process (this is achieved using the “Analysis Case” function). The AFS remains constant until the user makes an active choice to change -- planners involved in the design requested this approach as it allows faster processing of multiple actions at a single deficient site (a primary purpose of

ITMS). Changing the analysis case is somewhat slow as it requires rebuilding the entire statewide active file set from scratch – the temporary file acts only on those segments selected for the action or strategy.

Exhibit 6-3
Person Mode Shift Model Flow



2. Freight Flow Processor

The Freight Flow Processor (FFP) is the Freight Equivalent of the Person Mode Shift model. The FFP is a new feature in ITMS Version 3. Previous ITMS versions were unable to model the impact of actions or strategies on goods movement. The FFP allows the ITMS to model the effect of an action or strategy on freight movement in California. Both route diversion and mode shifts are considered.

Incorporating a freight flow processor into the ITMS fills a gap in existing modeling capabilities. Regional travel demand models generally do not capture goods movement and focus on travel within particular regions even through goods movement can occur over extremely long distances (e.g., across the state or across the county). In addition, simpler methods, such as using the Institute of Transportation Engineers (ITE) Trip Generation book, do not exist for goods movement.

The FFP is designed to help planners conduct simple “what-if” analyses to answer questions frequently posed by decision and policy makers:

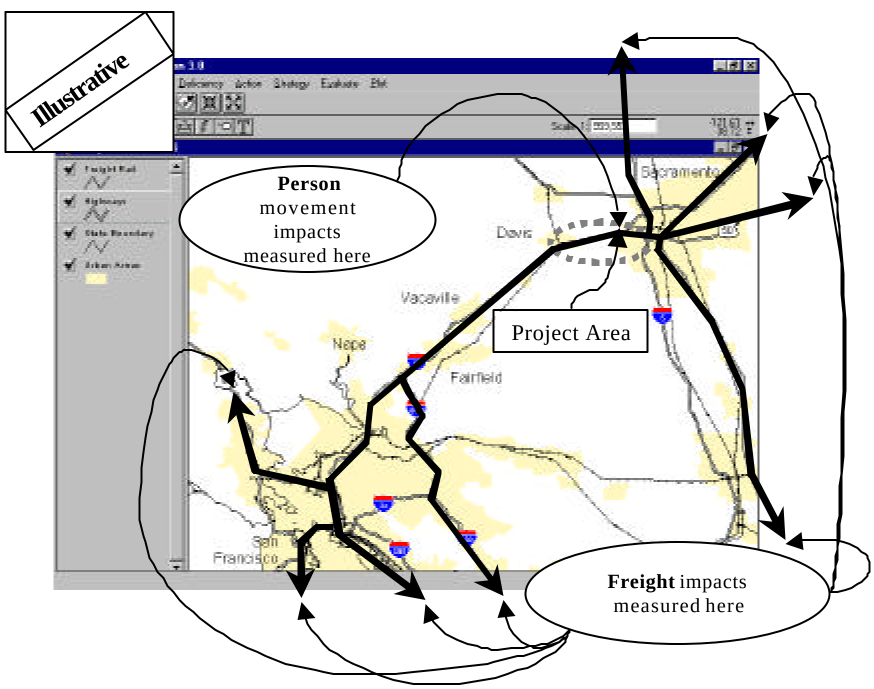
- What truck routing impacts would result from the loss of a major highway link (e.g., the Bay Bridge in 1989)?

- What would be the impact of proposed truck-only lanes on nearby truck and rail traffic (i.e., mode share, mobility, safety, and environmental impacts)?

- Would re-opening an abandoned short-line railway serving a port significantly reduce truck traffic on a neighboring state highway?

Unlike the person mode shift model, the FFP analyzes impacts between origin-destination pairs. This difference is illustrated in Exhibit 6-4. For a project along a segment (in the example, a highway project on I-80 between Davis and Sacramento), the person movement module evaluates mode shifts and performance impacts at the project level. The FFP, in contrast, measures the impacts at the origin and destination (OD) pair level. Origins are evaluated at the county level for rural and small urban counties and at lower levels of aggregation for metropolitan areas.

Exhibit 6-4
Area of Impact for Freight Movement versus Person Movement



The unique nature of freight and goods movement makes this approach necessary. Unlike person travel, which is considered to be largely intra-regional (i.e., less than 25 miles per trip on average), freight tends to travel over much longer distances.

As a general rule, goods tend to travel by truck for relatively short hauls of 100 miles or less. At distances of greater than 400 miles, rail becomes competitive for many goods. Between these two ranges, mode shift decisions depend on a number of factors. These factors include cost, time urgency of the good, the level of competition among travel modes between OD pairs, and the fragility of the good. Therefore, it is important to analyze impacts at the commodity level as well as at the level of the ultimate origin and ultimate destination of that good. The FFP considers the impacts at the commodity level as well as for any segment under analysis. In addition, the FFP considers both local and pass-through movements.

As with the person mode shift model, the FFP is based on the concept of generalized costs. While travel time is an important factor in the freight movement industry, other cost factors play a role. Each state levies its own taxes and fees on the trucking and rail industries. Interstate travel affects a large percentage of California goods. Shipping and routing decision for interstate travel depend on the lowest cost route. Even if an improvement along I-80 in California may greatly improve travel times for trucks to the rest of the country, a firm may not ship along that route if Nevada or any combination of states along that route has policies or other issues that increase the cost of shipping. In this hypothetical situation, a shipper may choose to ship by rail or along the I-10 corridor through Arizona instead of routing the commodity along that corridor.

2.1 Evaluation Process

Freight movement is more complicated and influenced by more factors than is person movement. Freight movement does not follow the traditional four-step model used for person demand. As a result, it was necessary to develop a separate module for the ITMS that describes the behavior of freight movements. Freight “behavior” depends on more factors than those considered in person-movement modeling:

- Short versus long haul
- Strategic alliances
- Cost of transportation
- In-house versus for-hire
- Commodity weight
- Amount shipped
- Fragility of good
- Time urgency.

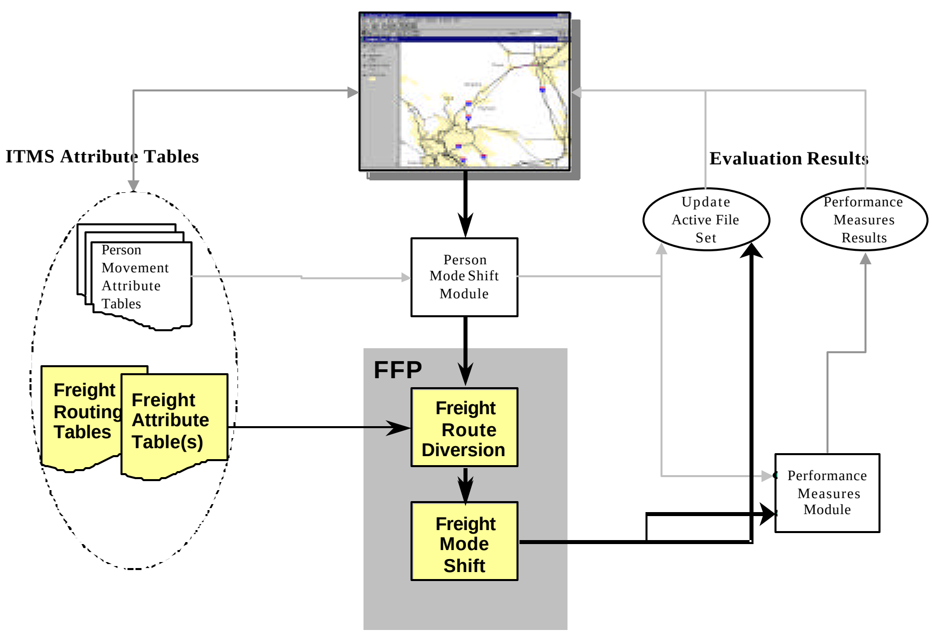
Freight comprises a small, but important, portion of traffic. Freight tends to travel longer distances than person trips. In addition, freight movement generally does not follow the typical a.m./p.m. peak commute pattern.

Modeling freight behavior is further complicated by the fact that private freight movement companies do not want to share their internal data for competitive reasons. Even when these companies provide sample data, they do so with strict restrictions (e.g., rail waybill).

The ITMS models changes in movement to actions or plans by considering both route diversions and mode shifts. Each of these responses is considered in a separate module of the FFP that must interact with the rest of the ITMS.

Exhibit 6-5 shows the process used by the FFP to evaluate the effect of actions or plans on goods movement. The process begins in the same way that the person mode shift model processes actions and strategies. In the exhibit, the person and freight movement analysis modules lie below the ITMS Graphical User Interface (GUI) and between the ITMS attribute tables and evaluation results. The dark connection lines represent the flow of data or information through the FFP. Light connector lines show other flow not directly related to the functionality of the FFP.

Exhibit 6-5
Freight Flow Processor Interaction with ITMS



When the user activates the evaluation or analysis case modules in the ITMS, an Avenue program creates a temporary parameter file that is passed to the person mode shift model. This parameter file contains the action attributes as well as transportation network supply and demand data from the modal attribute files.

The person mode shift model evaluates the segment impacts of a project. The results of this evaluation are passed into a temporary file for processing by the performance measure module and by the FFP. Data items required by the processor include: segment identification, network access price changes, travel time changes estimated by the mode shift model, and travel distance changes (i.e., due to a route realignment). Several important parameters from the action creation step and from the person mode shift module are passed to the FFP as shown in Exhibit 6-6.

Exhibit 6-6
Parameters Passed to the FFP

Parameter	Passed from
Freight Route Identifiers	Action (ITMS GUI)
Change in Access Price	Action (ITMS GUI)
Base Travel Time	Person Mode Shift Module
New Travel Time	Person Mode Shift Module

The person mode shift model then calls the FFP. This processor contains two main elements: the freight route diversion element which estimates routing changes within the same mode, and the freight mode shift model which calculates changes between competing modes (rail and truck). The following sections describe the sub-elements of the FFP in more detail.

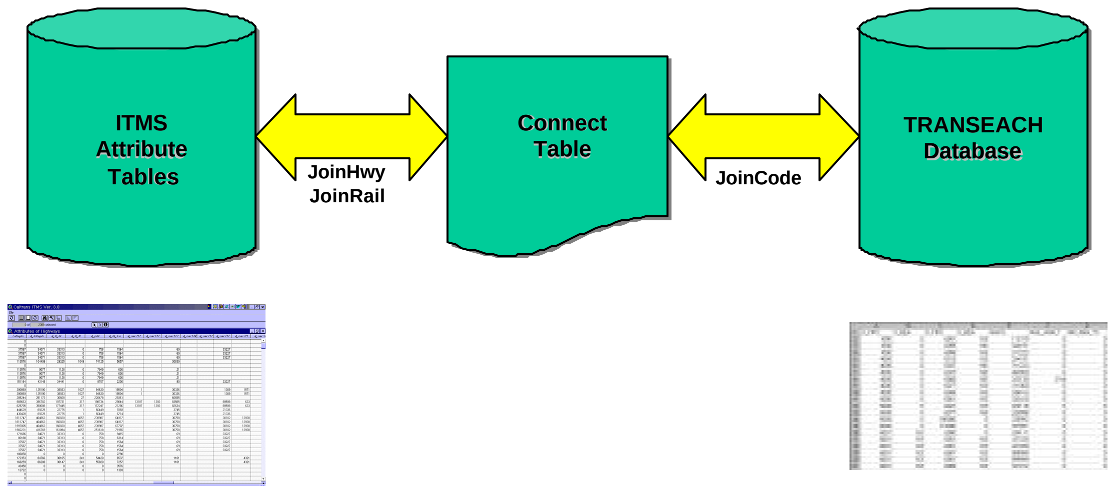
2.1.1 Route Diversion

The route diversion module considers how the action or strategy chosen by the user affects freight routing. Unlike in a regional travel demand model, the route diversion routine is called before the mode shift is calculated. This is because freight costs and routing depend on several factors, such as the equipment used and distance traveled, other than simply congestion. For the ITMS, four alternative routes have been developed for each origin and destination by commodity. The FFP selects the appropriate routing from among the pre-determined routings using a least cost algorithm, taking into account changes due to proposed actions or strategies. The development of alternative routings is described in a later section.

The FFP begins by identifying the TRANSEARCH records affected by the action or strategy (as a primary or alternative route) as well as all highway segments impacted by the identified TRANSEARCH records (as a primary or alternative route) and storing this information in a temporary database. This is challenging because of the many-to-many relationship between the ITMS attribute tables and the TRANSEARCH data. Each highway / rail segment can be used by many freight flows (defined by origin-destination and commodity). Each flow can also travel over multiple segments. As illustrated in Exhibit 6-7, a "connect table" matches the ITMS attribute tables and the

TRANSEARCH database. The ITMS attribute tables are linked to the freight data via unique field identifiers.

Exhibit 6-7
Relationship Between Freight Data Tables



A separate connect table exists for both highway and rail modes. Since transportation improvements are expected to occur in the future, different connect files are available for each of the four analysis years included in the ITMS: 1996, 2006, 2016, and 2026. The base year (1996) connect file includes routing alternatives based upon the existing highway and rail systems. Future year files consider planned and programmed transportation improvements.

The connect files are very large – each contains over 9 million records. As shown in Exhibit 6-8, each connect file includes three fields. In the highway connect files, the JoinHwy field links the connect table to ITMS highway attribute tables. Separate JoinHwy fields are provided for the A and B directions in the highway attribute table to allow the ITMS to assign the freight traffic correctly to the A and B directions of the highway attribute table. Each highway alternative is given a priority from 1 to 4. Separate flows are provided for hazardous materials (hazmat), which are assigned priorities 5 to 8. Priority 5 is the primary routing for hazardous materials. The JoinCode field links each of the alternative routings to the enhanced California TRANSEARCH database include in the ITMS. This database is described further in Chapter 3 on Freight Demand Data.

Exhibit 6-8
Connect File Data Dictionary

Field Name	Field Description	Type	Units
Priority	Route priority code: 1=Primary Routing (this is how the base case is assigned), 2-4=Secondary through fourth route alternatives, 5-8 hazmat routing alternatives	Numeric	Code
JoinCode	Code to Join Transearch California Database to the connect database	Numeric	Code
JoinHwys*	Code to Join the Connect Database to the ITMS Highways attributes file	Numeric	Code
JoinRail*	Code to Join the Connect Database to the ITMS Rail attributes file	Numeric	Code

** Only one of these fields is included depending on whether the file is a rail or highway connect file.*

The rail connect files include similar fields to the highway connect files, except that the JoinHwy field is replaced by a JoinRail field that links the connect file to the ITMS rail attribute file. As with the highway attribute file, the rail attribute file includes JoinRail fields for both the A and B directions to ensure that freight flows are correctly assigned by directions.

Once the appropriate TRANSEARCH records and impacted highway segments are identified, the cost fields in the temporary database are updated based on the action/strategy. The minimum-cost routing for each record is identified and selected.

2.1.2 Mode Shifts

Mode shifts are calculated for every TRANSEARCH record affected by the action/strategy. The calculation is conducted separately for every origin-destination commodity flow, and the appropriate model is selected based on commodity type. The FFP locates the corresponding coefficients and constant for the appropriate commodity model. For each TRANSEARCH record, the FFP calculates new annual tonnage by mode and updates the truck count. The appropriate ITMS coverage (i.e., highway or rail) is then updated. This process is described further in this section.

After the route diversion is calculated, the FFP considers mode choice. Freight mode choice is estimated using a logit model specifically developed for each commodity type by the North American Industry Classification System (NAICS). The development of the mode shift models and their specifications are explained in Section 2.3.

The FFP calculates the mode shift for each commodity O-D flow (i.e., record in the temporary file) one at a time. The FFP begins by looking up the calibrated logit model for the particular commodity in the logit model table. This table provides the appropriate coefficients and constants depending on the commodity type. A data dictionary for the logit model table is provided in Exhibit 6-12.

The table also identifies which of two types of logit models is being used. Every one of the 349 NAICS commodity groups was classified into one of two model types:

- Rail-Truck (RT): 115 NAICS commodities that can be hauled by the railroad in carload lots or by motor carrier on the highway

- Intermodal-Truck (IT): 234 NAICS commodities that are considered to be intermodal-truck competitive. For every origin-destination pair that did not carry at least five percent of all highway and rail shipments by intermodal, the origin-destination pair was considered to not be valid for intermodal shipments.

Only one model exists for each NAICS code. For example, NAICS 311615 (Poultry Processing) uses an RT model.

Once the appropriate model type and coefficients have been determined, the FFP follows the steps and uses the equations outlined in Section 2.1.2.2 to estimate the mode shift due to the action or strategy. The FFP uses the same five steps (for RT models) or six steps (for IT models) for each record in the temporary file.

After the FFP processes one record in the temporary file, it continues to the next record until mode shifts have been estimated for all records in the temporary file. Once all records have been processed, the FFP adds the data in the temporary file back to the ITMS attribute file using the connect file and calculates performance measures for the user. The performance measures calculated are described in Chapter 7.

2.1.2.1 Mode Shift Variables

The mode shift equations, which are described in the next section, use the following variables:

- **D_BEA, Destination BEA Field** – identifies destination for O-D commodity flow

- **D_FIPS, Destination FIPS Field** – identifies destination for O-D commodity flow

- **EligPer, Eligible Percent** – percentage of state freight flow from BEAs with intermodal freight alternatives (from eligible percent table)

- **Est_Trk_Cnt, Estimated Truck Count** – estimated number of trucks used for O-D commodity flow

- **FHLTL_Ann_Tons, For-Hire Less-Than-Truckload Annual Tons** – for O-D commodity flow

- **FHT_Ann_Tons, For-Hire Truckload Annual Tons** – for O-D commodity flow

- **IMXcoef, Intermodal Coefficient** – for IT equation from Logit Model Table

- **IMXprob, Intermodal Probability** – estimated intermodal market share for O-D commodity flow using IT model

- **NAICS, NAICS Commodity Code** – commodity identified by 6-digit code

- **NewConst, New Constant** – New constant for calibrating logit model to specific O-D

- **O_BEA, Origin BEA Field** – identifies origin for O-D commodity flow

- **O_FIPS, Origin FIPS Field** – identifies origin for O-D commodity flow

- **PrivTrk_Ann_Tons, Private Truck Annual Tons** – for O-D commodity flow

- **Rail_Ann_Tons, Rail Annual Tons** – for O-D commodity flow

- **Railcoef, Rail Coefficient** – for RT equation from Logit Model Table

- **Railcost, Rail Cost** – cost to ship one ton of commodity from origin to destination by rail on for appropriate alternative

- **RailProb, Rail Probability** – estimated rail market share for O-D commodity flow using RT model

- **TotalITAnnTon, Total IT Annual Tons** – total annual tons moved by intermodal and truck for O-D commodity flow

- **TotalRTAnnTon, Total RT Annual Tons** – total annual tons moved by rail and truck for O-D commodity flow

- **TotalTruckAnnTon, Total Truck Annual Tons** – total annual tons moved by FHT, FHLTL, and private truck for O-D commodity flow

- **Truckcoef, Truck Coefficient** – for IT or RT equation from Logit Model Table

- **Truckcost, Truck Cost** - cost to ship one ton of commodity from origin to destination by truck on for appropriate alternative

2.1.2.2 Mode Shift Equations

For each commodity O-D record in the temporary database, the freight flow processor uses the following steps to estimate mode shares based upon the appropriate logit model:

STEP 1: Calculate Existing Mode Shares

TotalTruckAnnTon = FHT_Ann_Tons + FHLTL_Ann_Tons + PrivTrk_Ann_Tons

If RT Model:
TotalRTAnnTon = Rail_Ann_Tons + TotalTruckAnnTon
RailProb = Rail_Ann_Tons / TotalRTAnnTon

If IT Model:
TotalITAnnTon = IMX_ANN_TO + TotalTruckAnnTon
IMXprob = IMX_ANN_TO / TotalITAnnTon

STEP 2: Determine Whether O-D Record Should Be Processed

If RT Model:
If RailProb = 0 or 1, then RailProb is unchanged and stop processing record

If IT Model:
If EligPer = 0, then intermodal share considered to be too small and stop processing record
If IMXprob = 0 or 1, then IMXprob is unchanged and stop processing record

STEP 3: Calibrate Logit Model to Specific O-D

If RT Model:

NewConst = ln[RailProb / (1-RailProb)] – railcoef*railcost – truckcoef*truckcost

If IT Model:

NewConst = ln[IMXprob / EligPer / (1-IMXprob / EligPer)] – IMXcoef*IMXcost – truckcoef*truckcost

STEP 4: Estimate New Mode Shares using Calibrated Model

If RT Model:

NewRailProb = 1 / [1 + exp(-NewConst – railcoef*railcost – truckcoef*NewTruckCost)]

NewTruckProb = 1 – NewRailProb

If IT Model:

NewIMXProb = 1 / [1 + exp(-NewConst – IMXcoef*IMXcost – truckcoef*NewTruckCost)] * EligPer

NewTruckProb = 1 – NewIMXProb

STEP 5: Recalculate Annual Tons and Truck Counts to Reflect New Mode Shares

If RT Model:

Rail_Ann_Tons = NewRailProb * TotalRTAnnTon

If IT Model:

IMX_ANN_TO = NewIMXProb * TotalITAnnTon

For Both Models:

FHT_Ann_Tons = (FHT_Ann_Tons / TotalTruckAnnTon) * NewTruckProb * TotalRTAnnTon

FHLTL_Ann_Tons = (FHLTL_Ann_Tons / TotalTruckAnnTon) * NewTruckProb * TotalRTAnnTon

PrivTrk_Ann_Tons = (PrivTrk_Ann_Tons / TotalTruckAnnTon) * NewTruckProb * TotalRTAnnTon

EST_TRK_CNT = (EST_TRK_CNT / TotalTruckAnnTon) * NewTruckProb * TotalRTAnnTon

<u>STEP 6A</u>: Update Truck Drayage at Origin (if IT Model)

Find records with same O_FIPS or O_BEA as current record and NAICS = 488000

Calculate change in IMX_ANN_TO for current record and add proportionately to the FHT_Ann_Tons field in each of the located Transearch records according to existing proportion (i.e., IMXprop1 = IMX_ANN_TO1 / Sum of all IMX_ANN_TO)

For each record calculate:

TOT_ANN_TO = Rail_Ann_Tons + IMX_ANN_TO + FHT_Ann_Tons + FHLTL_Ann_Tons + PrivTrk_Ann_Tons + AIR_ANN_TO + H20_ANN_TO

EST_TRK_CNT = (EST_TRK_CNT / TotalTruckAnnTon) * NewTruckProb * TotalITAnnTon

TRUCK_EQ = (TRUCK_EQ / Old value of TOT_ANN_TO) * TOT_ANN_TO

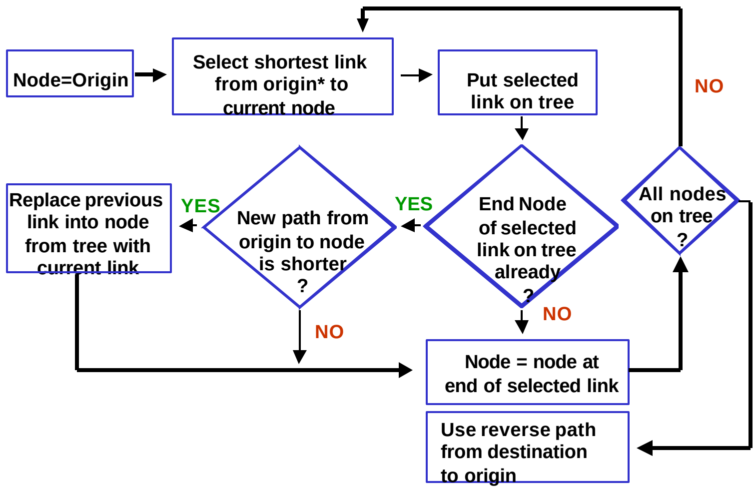
<u>STEP 6B</u>: Update Truck Drayage at Destination (if IT Model)

Same as Step 6a, but find records with D_FIPS or D_BEA same as current record

2.2 Routing Assignments

As illustrated in Exhibit 6-9, the initial highway routing assignments were made using a generalized least cost algorithm using impedance factors. For each origin node to destination node, a flow is assigned over the routing path with the lowest impedance. The impedance is a measure of desirability for each link in the network. This measure attempts to quantify a variety of factors that contribute to a truck selecting a particular route. This basic data is used to create an initial routing assignment that is then checked against the truck count data. The impedance for individual links is then adjusted in an iterative process to produce assignments that more closely match the truck count data.

Exhibit 6-9
Procedure for Developing Initial Highway Assignments



The first step in making the highway routing assignments is to establish an impedance for each node-to-node link in the network. This initial impedance is calculated as travel time, based on reported average speed and the length of the segment. Using this impedance data, the least path routing algorithm is run, and the assigned volumes to each link is compared with truck count data.

It is difficult to compare the ITMS freight assignments to Caltrans truck estimates. Caltrans counts trucks by number of axles (i.e., 2 axles, 3 axles, 4 axles, and 5+ axles). Information on California truck volumes is available from two Caltrans sources:

- Annual Average Daily Truck Traffic on the California State Highway System – This is a published book that was last produced in October 1997. The book included verified, unverified, and estimated counts. Some counts are over 10 years old.

- Weigh-In-Motion (WIM) data – There are 36 stations statewide. Only 35 stations are in current operation. The WIM data are considered to be the most reliable truck data available in California.

The ITMS truck assignments should be compared primarily to the weigh-in-motion data. Caltrans truck counts are available for over 200 ITMS segments, but the WIM estimates are considered to be the most reliable set of data.

The ITMS assignments should fall somewhere in between the 2-axle truck count (minimum estimate) and the total truck count (maximum estimate). The ITMS data must be converted from tons to number of trucks using a standard conversion factor. The freight data in the ITMS does not consider trucks on the freeway for non-freight movement (e.g., transportation of construction equipment). Exhibit 6-10 illustrates the complexity of comparing Caltrans truck counts to ITMS freight allocations.

Exhibit 6-10
Typical Truck Count to ITMS Comparison

Case	District	Route	County	ITMS Segment Location		Count Station Location(s)		Ahead Leg Count Data				
				ITMS_ID	ITMS PostMile	Post Mile	Intersection	2 Axle Trucks	3 Axle Trucks	4 Axle Trucks	5+ Axle Trucks	Total Trucks
1 Count Station 1 Direction	5	1	SCR	AMBAG_2394_2395	R6.690/17.070	15.0	SOQUEL AVENUE	2,390	538	102	608	3,638
1 Station 2 Directions	7	91	LA	SCAG_8801_8802	3.070/R6.344	6.3	JCT. RTE. 110	7,507	1,453	439	5,737	15,136
3 Stations 2 Directions	4	84	SM	MTC_5922_5939	25.72/R30.149	26.0	MENLO PARK, JCT. RTE. 101	1,055	171	71	215	1,512
						28.0	JCT. RTE. 109					
						29.0	DUMBARTON BRIDGE					

Case	Behind Leg Count Data					Caltrans Truck Count Estimates			Estimated Reebie ITMS FCEs		
	2 Axle Trucks	3 Axle Trucks	4 Axle Trucks	5+ Axle Trucks	Total Trucks	Min (5+ Axle)	Max (Total)	FCEs	A Dir. Annual	B Dir. Annual	Average Daily (Ann./365)
1 Count Station 1 Direction						608	3,638	1,968	248,372	285,350	1,462
1 Station 2 Directions	1,724	252	120	505	2,601	505	15,136	5,702	456,978	59,864	1,416
3 Stations 2 Directions						215	2,470	1,081	66,865	33,026	274
	857	165	57	451	1,530						
	1,371	267	165	667	2,470						

There are several other issues to consider in comparing the ITMS freight data to other data sources:

- Seasonal routes - Some routes are used more heavily in the winter (e.g. Route 97 in Siskiyou County).

- Seasonal freight movement - Some freight is shipped during only certain seasons (e.g., agricultural products).

- Truck routes - Some routes are specially designated as truck routes, while trucks are prohibited from using other routes (e.g., I-580 in Northern California).

Each of these complexities were considered when making the freight assignments and calibrating the assignments to actual truck counts. Where assignments were high, the impedance was increased, and where assignments were low, impedance was decreased. This process was repeated over 40 times until the assigned results were brought into line with the observed truck count data.

This iterative procedure was established as being the most effective after several attempts were made to create initial impedance for each link using more detailed information. These attempts included using only peak average speeds, using only non-peak average speeds, and adding additional impedance for tolls and other specific factors. However, since the ultimate approach used a technique whereby impedance levels were adjusted to obtain a predetermined result, the derived impedance more accurately reflects real world conditions than any engineered impedance values would.

Some deviations between the ITMS assignments and actual truck counts should be expected. The ITMS freight assignments assume that non-manufactured freight remains within California. The commercial version of the TRANSEARCH database does not include information on non-manufacturing freight movement. Reebie Associates added non-manufacturing data for the Caltrans version, which was allocated based on local production and consumption within California. This allocation ignores the fact that some non-manufacturing products may leave California in border areas (e.g., lumber in Northern California). In addition, the ITMS assignments exclude trucks not involved in freight movement (e.g., transportation of construction equipment).

Reebie Associates also added information on trade with Mexico to the TRANSEARCH database. This trade information is available only at the state-to-state level. This may impact freight assignments, particularly in San Diego County.

A separate network was used to assign hazardous material (hazmat) movements. This network does not include segments where hazmat movements are prohibited. The same iterative process described above was used to develop hazmat routings.

Separate networks are also used to assign highway routings in future years (e.g., 2006, 2016, and 2026). These networks differ from the base year (1996) network in that they include additional highway segments expected to open by the particular forecast year. The basic iterative procedure described above was used to assign freight movements to the future year networks.

Rail routings were also assigned using a least path algorithm. Since the rail network is far less intricate than the highway network, the iterative process was much more limited. The complete ITMS database includes four alternative routing assignments for each freight flow and both highway and rail modes.

2.3 Mode Choice Model Estimation

A separate mode choice model was developed for each commodity type. A model was initially estimated for each of 167 three-digit STCC groups. The estimates were based on data in the commercially available CostLine database. The initial estimates were later translated into the NAICS format using the standard conversion table shown in Exhibit 6-11.

Exhibit 6-11
Conversion Between NAICS and SIC Industry Classification Codes

North American Industry Classification System (NAICS)	Standard Industrial Classification Codes (SIC)	NAICS Description
111110	11	Oil Kernels, Nuts or Seeds
111140	11	Grain
111219	13	Other Vegetable (except Potato) and Melon Farming (pt)
111300	12	Fruits
111400	84	Barks or Gums, Crude
111900	11	Farm Products, NEC
111920	11	Cotton, Raw
112100	14	Dairy Farm Products
112112	14	Cattle Feedlots
112310	15	Poultry Eggs
112320	15	Live Poultry
112500	98	Fish Hatcheries
112900	14	Animal Fibers
112930	19	Animal Specialties
113100	86	Misc. Forest Products
113310	241	Primary Forest Materials
114100	91	Marine Products
211111	131	Crude Petroleum and Natural Gas Extraction
211112	132	Natural Gas Liquid Extraction (pt)
212111	112	Bituminous Coal and Lignite Surface Mining
212113	111	Anthracite Mining
212210	101	Iron Ores
212221	104	Gold Ore Mining
212222	104	Silver Ore Mining
212231	103	Lead Ore and Zinc Ore Mining
212234	102	Copper Ore and Nickel Ore Mining (pt)
212291	109	Uranium-Radium-Vanadium Ore Mining

212299	105	All Other Metal Ore Mining (pt)
212311	141	Dimension Stone Mining and Quarrying
212312	142	Crushed and Broken Limestone Mining and Quarrying
212321	144	Construction Sand and Gravel Mining
212324	145	Kaolin and Ball Clay Mining
212393	147	Other Chemical and Fertilizer Mineral Mining
212399	149	All Other Nonmetallic Mineral Mining (pt)
311111	204	Dog and Cat Food Manufacturing
311211	204	Flour Milling (pt)
311212	204	Rice Milling
311213	208	Malt Manufacturing
311221	204	Wet Corn Milling
311222	209	Soybean Processing (pt)
311223	209	Other Oilseed Processing (pt)
311225	209	Fats and Oils Refining and Blending (pt)
311300	207	Candy or Other Confectionery
311311	206	Sugarcane Mills
311312	206	Cane Sugar Refining
311411	203	Frozen Fruit, Juice, and Vegetable Manufacturing
311421	203	Fruit and Vegetable Canning (pt)
311422	203	Specialty Canning
311423	203	Dried and Dehydrated Food Manufacturing (pt)
311511	202	Fluid Milk Manufacturing
311512	202	Creamery Butter Manufacturing
311513	202	Cheese Manufacturing
311514	202	Dry, Condensed, and Evaporated Dairy Product Manuf.
311520	202	Ice Cream or Related Frozen Desserts
311611	201	Animal (except Poultry) Slaughtering (pt)
311615	201	Poultry Processing
311711	203	Seafood Canning (pt)
311712	203	Fresh and Frozen Seafood Processing (pt)
311812	205	Commercial Bakeries (pt)

311813	203	Frozen Cakes, Pies, and Other Pastries Manufacturing
311821	205	Cookie and Cracker Manufacturing
311822	204	Flour Mixes and Dough Manuf. from Purchased Flour
311823	209	Dry Pasta Manufacturing (pt)
311920	209	Roasted or Instant Coffee
311930	208	Misc. Flavoring Extracts
311999	203	All Other Miscellaneous Food Manufacturing (pt)
312110	208	Soft Drinks or Mineral Water
312113	209	Ice Manufacturing
312120	208	Malt Liquors
312130	208	Wine, Brandy or Brandy Spirit
312140	208	Distilled or Blended Liquors
312210	214	Stemmed or Redried Tobacco
312221	211	Cigarette Manufacturing
312229	212	Other Tobacco Product Manufacturing (pt)
313111	228	Yarn Spinning Mills (pt)
313113	228	Thread Mills (pt)
313210	221	Woven Fabrics
313221	224	Narrow Fabric Mills (pt)
313230	229	Textile Goods, NEC
313320	229	Coated or Imprinted Fabric
314110	227	Carpets, Mats or Rugs, NEC
314121	239	Curtain and Drapery Mills (pt)
314129	239	Other Household Textile Product Mills (pt)
314911	239	Textile Bag Mills (pt)
314912	239	Canvas and Related Product Mills (pt)
314991	229	Rope, Cordage, and Twine Mills
314992	229	Tire Cord and Tire Fabric Mills
314999	229	All Other Miscellaneous Textile Product Mills (pt)
315000	231	Clothing, NEC
315190	225	Knit Fabrics
315220	238	Raincoats or Other Rain Wear

315230	238	Robes or Dressing Gowns
315292	237	Fur and Leather Apparel Manufacturing (pt)
315991	235	Hat, Cap, and Millinery Manufacturing
315999	238	Other Apparel Accessories & Other Apparel Manuf. (pt)
316110	311	Misc Leather & Fur Goods
316211	302	Rubber and Plastics Footwear Manufacturing
316212	314	House Slipper Manufacturing
316213	314	Men's Footwear (except Athletic) Manufacturing
316219	313	Other Footwear Manufacturing
316991	316	Luggage Manufacturing
316999	315	All Other Leather Good Manufacturing (pt)
321113	242	Sawmills (pt)
321114	249	Wood Preservation
321210	243	Structural Wood Products, NEC
321212	243	Softwood Veneer and Plywood Manufacturing
321219	249	Reconstituted Wood Product Manufacturing
321912	242	Cut Stock, Resawing Lumber, and Planing (pt)
321918	243	Other Millwork (including Flooring) (pt)
321920	244	Wood Cont. or Box Shooks
321991	243	Manufactured Home (Mobile Home) Manufacturing
321999	249	All Other Miscellaneous Wood Product Manuf. (pt)
322110	261	Pulp or Pulp Mill Products
322121	262	Paper (except Newsprint) Mills (pt)
322130	263	Fiber, Paper or Pulpboard
322210	264	Pressed or Molded Pulp Goods
322211	265	Corrugated and Solid Fiber Box Manufacturing (pt)
322214	265	Fiber Can, Tube, Drum, and Similar Products Manuf.
322215	265	Nonfolding Sanitary Food Container Manufacturing
322222	264	Coated and Laminated Paper Manufacturing (pt)
322224	264	Uncoated Paper and Multiwall Bag Manufacturing
322231	264	Die-Cut Paper & Paperboard Office Supplies Manuf. (pt)
322232	264	Envelope Manufacturing

322291	264	Sanitary Paper Product Manufacturing (pt)
322299	264	All Other Converted Paper Product Manufacturing (pt)
323116	276	Manifold Business Forms Printing (pt)
323117	273	Books Printing
323118	278	Blankbook, Looseleaf Binders, and Devices Manuf.
323122	279	Prepress Services (pt)
324110	291	Petroleum Refining Products
324121	295	Asphalt Paving Mixture and Block Manufacturing
324122	295	Asphalt Shingle and Coating Materials Manufacturing
324190	331	Blast Furnace or Coke
324191	299	Petroleum Lubricating Oil and Grease Manufacturing
325000	281	Ind., Inorg. or Org. Chemicals
325100	281	Industrial Chemicals
325120	281	Industrial Gases
325131	281	Inorganic Dye and Pigment Manufacturing (pt)
325180	281	Misc. Industrial Inorganic Chemicals
325181	281	Alkalies and Chlorine Manufacturing
325190	281	Misc. Industrial Organic Chemicals
325191	286	Gum and Wood Chemical Manufacturing
325211	282	Plastics Material and Resin Manufacturing
325311	287	Nitrogenous Fertilizer Manufacturing
325320	287	Misc. Agricultural Chemicals
325412	283	Pharmaceutical Preparation Manufacturing (pt)
325510	285	Paints, Lacquers, Etc.
325520	289	Adhesives
325611	284	Soap and Other Detergent Manufacturing (pt)
325612	284	Polish and Other Sanitation Good Manufacturing
325613	284	Surface Active Agent Manufacturing
325620	284	Cosmetics, Perfumes, Etc.
325910	289	Printing Ink
325920	289	Explosives
325992	386	Photographic Film, Paper, Plate, and Chemical Manuf.

325998	289	All Other Misc. Chemical Product and Prep. Manuf. (pt)
326121	307	Unsupported Plastics Profile Shape Manufacturing (pt)
326190	303	Reclaimed Rubber
326192	399	Resilient Floor Covering Manufacturing (pt)
326199	307	All Other Plastics Product Manufacturing (pt)
326211	301	Tire Manufacturing (except Retreading)
326220	304	Rubber or Plastic Hose or Belting
326291	306	Rubber Product Manufacturing for Mechanical Use
327111	326	Vitreous China Plumbing Fixture & Earthenware Bathroom Acc. Manuf.
327112	326	Vitreous China, Fine Earthenware, & Other Pottery Production Manuf. (pt)
327113	326	Porcelain Electrical Supply Manufacturing
327121	325	Brick and Structural Clay Tile Manufacturing
327122	325	Ceramic Wall and Floor Tile Manufacturing
327123	325	Other Structural Clay Product Manufacturing
327124	325	Clay Refractory Manufacturing
327210	321	Laminate Safety Glass
327211	321	Flat Glass Manufacturing
327213	322	Glass Container Manufacturing
327215	322	Glass Product Manufacturing Made of Purchased Glass
327300	327	Concrete Products
327310	324	Portland Cement
327320	327	Ready-Mix Concrete, Wet
327410	327	Lime or Lime Plaster
327420	327	Gypsum Products
327910	329	Abrasive Products
327991	328	Cut Stone and Stone Product Manufacturing
327993	329	Mineral Wool Manufacturing
327999	329	All Other Misc. Nonmetallic Mineral Product Manuf. (pt)
331100	331	Primary Iron or Steel Products
331112	331	Electrometallurgical Ferroalloy Product Manufacturing
331222	331	Steel Wire Drawing
331312	333	Primary Aluminum Production

331315	335	Aluminum Sheet, Plate, and Foil Manufacturing
331330	348	Misc. Fabricated Wire Products
331411	333	Primary Smelting and Refining of Copper
331419	333	Primary Smelting & Refining of Nonferrous Metal (ex. Copper & Aluminum)
331420	335	Nonferrous Wire
331421	335	Copper Rolling, Drawing, and Extruding
331491	335	Nonferrous Metal (ex. Copper & Alum.) Rolling, Drawing, & Extruding (pt)
331511	332	Iron Foundries (pt)
331521	336	Aluminum Die-Casting Foundries
331522	336	Nonferrous (except Aluminum) Die-Casting Foundries
332100	331	Cold Finishing or Steel Shapes
332111	339	Iron and Steel Forging
332112	339	Nonferrous Forging
332211	342	Cutlery and Flatware (except Precious) Manuf. (pt)
332212	342	Hand and Edge Tool Manufacturing (pt)
332213	342	Saw Blade and Handsaw Manufacturing
332311	344	Prefabricated Metal Building and Component Manuf.
332312	344	Fabricated Structural Metal Manufacturing (pt)
332313	344	Plate Work Manufacturing
332321	344	Metal Window and Door Manufacturing (pt)
332322	344	Sheet Metal Work Manufacturing
332323	344	Ornamental and Architectural Metal Work Manuf. (pt)
332431	341	Metal Can Manufacturing
332439	349	Other Metal Container Manufacturing (pt)
332510	349	Metal Safes or Vaults
332611	349	Spring (Heavy Gauge) Manufacturing
332720	342	Builders or Cabinet Hardware
332722	345	Bolt, Nut, Screw, Rivet, and Washer Manufacturing (pt)
332900	349	Fabriacted Metal Products, NEC
332913	343	Plumbing Fixture Fitting and Trim Manufacturing
332991	356	Ball and Roller Bearing Manufacturing
332992	196	Small Arms Ammunition Manufacturing

332993	192	Ammunition (except Small Arms) Manufacturing
332994	195	Small Arms Manufacturing (pt)
332995	190	Other Ordnance and Accessories Manufacturing
332998	343	Enameled Iron and Metal Sanitary Ware Manufacturing
332999	342	All Other Misc. Fabricated Metal Product Manuf. (pt)
333000	355	Misc. Special Industry Machinery
333111	352	Farm Machinery and Equipment Manufacturing
333112	352	Tractor & Home Lawn and Garden Equip. Manuf.
333120	353	Construction Machinery or Equipment
333131	353	Mining Machinery and Equipment Manufacturing
333132	353	Oil and Gas Field Machinery and Equipment Manuf.
333210	355	Woodworking Machinery
333291	355	Paper Industry Machinery Manufacturing
333292	355	Textile Machinery Manufacturing
333293	355	Printing Machinery and Equipment Manufacturing
333294	355	Food Product Machinery Manufacturing
333298	363	All Other Industrial Machinery Manufacturing (pt)
333311	358	Automatic Vending Machine Manufacturing (pt)
333312	358	Commercial Laundry, Drycleaning, and Pressing Machine Manufacturing
333313	357	Office Machinery Manufacturing (pt)
333314	194	Optical Instrument and Lens Manufacturing
333319	358	Other Commercial & Service Ind. Machinery Manuf. (pt)
333400	358	Refrigeration Machinery
333410	356	Ventilating Equipment
333414	343	Heating Equip. (except Warm Air Furnaces) Manuf. (pt)
333510	354	Machine Tool Accessories
333512	354	Machine Tool (Metal Cutting Types) Manufacturing
333513	354	Machine Tool (Metal Forming Types) Manufacturing
333518	354	Other Metalworking Machinery Manufacturing
333611	351	Turbine and Turbine Generator Set Unit Manufacturing
333613	356	Mechanical Power Transmission Equipment Manuf.
333900	359	Misc. Machinery or Parts

333911	356	Pump and Pumping Equipment Manufacturing (pt)
333921	353	Elevator and Moving Stairway Manufacturing
333922	353	Conveyor and Conveying Equipment Manufacturing (pt)
333923	353	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing (pt)
333990	362	Welding Apparatus
333993	356	Packaging Machinery Manufacturing
333994	356	Industrial Process Furnace and Oven Manufacturing
333996	372	Fluid Power Pump and Motor Manufacturing
333997	357	Scale and Balance (except Laboratory) Manufacturing
334000	357	Misc. Electronic Components
334100	357	Accounting or Calculating Equipment
334111	357	Electronic Computer Manufacturing
334210	366	Telephone or Telegraph Equipment
334220	366	Radio or TV Transmitting Equipment
334310	365	Radio or TV Receiving Sets
334411	367	Electron Tube Manufacturing
334413	367	Semiconductor and Related Device Manufacturing
334511	381	Search, Detect., Nav., Guidance, Aeronautical, & Nautical Sys. & Instr. Manuf.
334512	382	Automatic Environmental Control Manuf. for Res., Com., & Appliance Use
334513	382	Inst. & Rel. Prod. Manuf. for Measuring, Disp., & Control Ind. Process Vars.
334516	383	Analytical Laboratory Instrument Manufacturing
334517	369	Irradiation Apparatus Manufacturing (pt)
334518	387	Watch, Clock, and Part Manufacturing (pt)
334612	365	Prerecorded Compact Disc (except Software), Tape, & Record Rep. (pt)
335000	361	Electric Measuring Instruments
335110	364	Electric Lamps
335122	364	Commercial, Industrial, and Institutional Electric Lighting Fixture Manuf.
335212	363	Household Vacuum Cleaner Manufacturing (pt)
335221	363	Household Cooking Appliance Manufacturing
335222	363	Household Refrigerator and Home Freezer Manuf.
335224	363	Household Laundry Equipment Manufacturing
335228	363	Other Major Household Appliance Manufacturing

335311	361	Power, Distribution, & Specialty Transformer Manuf. (pt)
335312	362	Motor and Generator Manufacturing (pt)
335313	361	Switchgear and Switchboard Apparatus Manufacturing
335314	362	Relay and Industrial Control Manufacturing
335900	364	Noncurrent Wiring Devices
335911	369	Storage Battery Manufacturing
335912	369	Primary Battery Manufacturing
335931	364	Current-Carrying Wiring Device Manufacturing
335991	362	Carbon and Graphite Product Manufacturing
335999	362	All Other Misc. Elec. Equip. & Component Manuf. (pt)
336000	351	Misc. Internal Combustion Engines
336110	371	Motor Vehicles
336211	371	Motor Vehicle Body Manufacturing (pt)
336212	371	Truck Trailer Manufacturing
336213	379	Motor Home Manufacturing
336300	371	Motor Vehicle Parts or Accessories
336311	359	Carburetor, Piston, Piston Ring, and Valve Manufacturing
336322	369	Other Motor Veh. Elec. & Electronic Equip. Manuf. (pt)
336370	346	Metal Stampings
336411	372	Aircraft Manufacturing (pt)
336412	372	Aircraft Engine and Engine Parts Manufacturing (pt)
336414	192	Guided Missile and Space Vehicle Manufacturing
336419	376	Other Guided Missile and Space Vehicle Parts and Auxiliary Equip. Manuf.
336510	374	Locomotives & RR Cars
336611	373	Ship Building and Repairing
336991	375	Motorcycle, Bicycle, and Parts Manufacturing (pt)
336992	193	Military Armored Vehicle, Tank, and Tank Component Manufacturing (pt)
336999	379	All Other Transportation Equipment Manufacturing
337000	251	House & Office Furniture, NEC
337110	243	Kitchen Cabinets, Wood
337120	251	Misc Furniture, NEC
337121	251	Upholstered Household Furniture Manufacturing (pt)

337127	253	Institutional Furniture Manufacturing (pt)
337210	251	Tables or Desks
337214	251	Office Furniture (except Wood) Manufacturing
337215	254	Showcase, Partition, Shelving, and Locker Manuf. (pt)
337910	251	Bedsprings or Mattresses
337920	259	Venetian Blinds, Shades, Etc.
339110	384	Orthopedic or Prosthetic Supplies
339113	384	Surgical Appliance and Supplies Manufacturing (pt)
339114	384	Dental Equipment and Supplies Manufacturing
339115	385	Ophthalmic Goods Manufacturing (pt)
339900	396	Feathers, Plumes, Etc.
339911	391	Jewelry (except Costume) Manufacturing (pt)
339912	391	Silverware and Hollowware Manufacturing (pt)
339914	396	Costume Jewelry and Novelty Manufacturing (pt)
339920	394	Sporting or Athletic Goods
339931	394	Doll and Stuffed Toy Manufacturing
339932	394	Game, Toy, and Children's Vehicle Manufacturing (pt)
339940	395	Pencils, Crayons, or Artists Materials
339941	395	Pen and Mechanical Pencil Manufacturing
339943	395	Marking Device Manufacturing
339944	395	Carbon Paper and Inked Ribbon Manufacturing
339950	399	Signs or Advertising Displays
339991	329	Gasket, Packing, and Sealing Device Manufacturing
339992	393	Musical Instrument Manufacturing
339993	396	Fastener, Button, Needle, and Pin Manufacturing (pt)
339994	399	Broom, Brush, and Mop Manufacturing (pt)
339995	399	Burial Casket Manufacturing
339999	363	All Other Miscellaneous Manufacturing (pt)
421930	401	Waste or Scrap
481000	503	Air Freight Drayage
482112	411	FAK Shipments
488000	502	Rail Intermodal Drayage

493000	501	Warehouse and Distribution Center
511100	274	Misc. Printed Matter
511110	271	Newspapers
511120	272	Periodicals
511191	277	Greeting Card Publishers

Each of the resulting 349 NAICS commodity groups was classified into one of two model types:

- Rail-Truck (RT): 115 NAICS commodities that can be hauled by the railroad in carload lots or by motor carrier on the highway

- Intermodal-Truck (IT): 234 NAICS commodities that are considered to be intermodal-truck competitive. For every origin-destination pair that did not carry at least 5 percent of all highway and rail shipments by intermodal, the origin-destination pair was considered to not be valid for intermodal shipments.

For O-D pairs of relatively short distance, almost 100 percent of the tonnage is assigned to truck only.

For commodities in the RT group, Reebie Associates calibrated a mode choice model using freight flows from its commercially available TRANSEARCH database and cost data from its Carrier CostLine database to develop equations of the following standard logit form:

$$P_i = \frac{1}{1 + e^{-(b_0 + b_1 C_1 + b_2 C_2)}}$$

The equation estimates the probability that the rail mode is chosen. The expression in the parentheses represents the utility of choosing the rail alternative. The utility is based upon the cost of each of the two modes (i.e., rail and truck) – these are the variables labeled C_1 and C_2. Each cost has an associated coefficient which is provided in the logit model table (see data dictionary in Exhibit 6-12). A separate model with unique coefficients is provided for each commodity in the RT group.

A similar set of logit equations were estimated for 234 NAICS commodities in the intermodal-truck (IT) group. The equations estimate the probability that the intermodal mode is chosen. As in the RT equations, the utility is based upon the cost of each of the modes. Unlike in the RT equations, these modes were considered to be intermodal and truck.

Exhibit 6-12
Data Dictionary for Logit Model Table

Field Name	Field Description	Type	Units
NAICS	NAICS Commodity Code (6-digit Code)	Numeric	Code
Description	Description of NAICS Commodity	Alpha	Description
Model	Designates Whether Intermodal-Truck or Rail-Truck model (IT or RT)	Alpha	Code
Constant	Constant for Logit Equation	Numeric	Factor
IMXcoef	Intermodal coefficient for IT equation	Numeric	Factor
RailCoef	Rail coefficient for RT equation	Numeric	Factor
TruckCoef	Truck coefficient for IT or RT equation	Numeric	Factor

To calibrate models, Reebie Associates used a TRANSEARCH file that includes freight costs from the Carrier CostLine database to generate a set of observed costs and market shares by BEA in the United States. Some coefficients were manually adjusted to produce results that closely correspond to observed behavior.

The Carrier Costline database recognizes that the rail and trucking industries have different cost structures. Even within a particular mode, there are differences in costs for shipping different commodities. In the trucking industry, for example, drivers who deliver more volatile commodities, such as fuel, tend to receive more training and higher wages than do drivers that deliver other goods, such as gravel. Exhibit 6-13 provides an example of the cost structure for rail and truck alternatives for transporting a commodity between San Francisco and Reno, Nevada.

Exhibit 6-13
Freight Transportation Cost Example

Origin: San Francisco
Destination: Reno, Nevada

TRUCKING Cost Element	Cost per Ton	RAIL Cost Element	Cost per Ton
Driver Wage	$ 7.81	Crew	$ 0.64
Fuel	$ 1.68	Fuel	$ 0.29
Tractor Ownership & Maint.	$ 3.56	Locomotives	$ 0.60
Trailer Ownership & Maint.	$ 0.59	Car	$ 1.11
Overhead	$ 8.19	Overhead	$ 2.50
Insurance	$ 0.94		
Fees & Taxes	$ 2.02		
		Yard & Terminal	$ 1.94
		Track & Right of Way	$ 0.66
TOTAL	**$ 24.79**	**TOTAL**	**$ 7.74**

Source: Reebie Associates Carrier CostLine

These cost elements were allocated into three ITMS cost categories as follows:

- Access to the transportation system (e.g., fees or tolls)
- Travel time (e.g., improved grade crossings or port-to-rail connections)
- Travel distance (e.g., more direct rail or highway alignment).

Any change in the transportation network will affect some element of cost. For example, rail grade-crossing improvements will increase rail speeds, reduce travel times, and result in a reduction of the time cost component for rail shipping costs. Likewise, the addition of a toll will increase the fee cost element for trucks and may induce a shift to rail.

In the case of intermodal traffic, IT models were developed that could be used for all commodities shipped in this way. When a dry van is presented to the railroad for shipment on one of its flat cars, railroad operating personnel seldom know what is in it. For that reason, all intermodal traffic behaves as though it belongs to STCC number 46111 (Freight All Kinds – FAK). As a result, all the intermodal shipments are grouped into a single block of data. Also, an assumption was made that it would be possible to ship any such commodities by truck as well as by rail so that these commodities could be placed in the IT (intermodal-truck) model group.

After combining all commodities in the IT group, Reebie Associates tested whether the model could be applied for each particular origin-destination pair since intermodal usage varies by geographic setting. It was observed that when an intermodal alternative is reasonably available, it competes well with other modes. Where it is not reasonably available, the intermodal market share is low. As a result, a market share threshold of five percent was established for each BEA origin-destination pair. If the intermodal share for a particular origin-destination was five percent or more, it was assumed that the origin-destination pair had reasonably available intermodal alternatives. If the mode share was less, the origin-destination was not considered valid for intermodal and removed from the model calibration.

Since the enhanced TRANSEARCH database included in the ITMS aggregates travel flows out of California by state rather than BEA, the calibrated IT models need to be adjusted by the percentage of BEA intermodal flows in each state. Applying the IT model without this adjustment will over-predict intermodal share for trips having one end outside of California.

The ITMS uses the calibrated IT model adjusted by percent eligible to arrive at the predicted intermodal flow. That percentage is equal to the proportion of a given state's flow for each commodity that is accounted for by the BEAs used in the calibration of the model. The percent eligible is provide separately for each State-California BEA combination by direction in the IT Eligible Percent Table. The data dictionary for this table is provided in Exhibit 6-14.

Exhibit 6-14
Data Dictionary for Eligible Percent Table

Field Name	Field Description	Type	Units
O_FIPS	Origin FIPS Field	Numeric	Code
O_BEA	Origin BEA Field	Numeric	Code
D_FIPS	Destination FIPS Field	Numeric	Code
D_BEA	Destination BEA Field	Numeric	Code
EligTons	Total Annual Tons Shipped from BEAs in State with Intermodal Freight Alternatives	Numeric	Annual Tons
TotTons	Total Annual Tons Shipped from State	Numeric	Annual Tons
EligPer	Percentage of State Freight Flow from BEAs with Intermodal Freight Alternatives	Numeric	Percentage

Exhibit 6-15 lists the FIPS codes used in the ITMS.

Exhibit 6-15
Numeric and Alpha FIPS Codes

Name	FIPS State Numeric Code	FIPS State Alpha Code
US States and the District of Columbia		
Alabama	01	AL
Alaska	02	AK
Arizona	04	AZ
Arkansas	05	AR
California	06	CA
Colorado	08	CO
Connecticut	09	CT
Delaware	10	DE
District of Columbia	11	DC
Florida	12	FL
Georgia	13	GA
Oklahoma	40	OK
Hawaii	15	HI
Idaho	16	ID
Illinois	17	IL
Indiana	18	IN
Iowa	19	IA
Kansas	20	KS
Kentucky	21	KY
Louisiana	22	LA
Maine	23	ME
Maryland	24	MD
Massachusetts	25	MA
Michigan	26	MI
Minnesota	27	MN
Mississippi	28	MS
Missouri	29	MO
Montana	30	MT
Nebraska	31	NE
Nevada	32	NV
New Hampshire	33	NH
New Jersey	34	NJ
New Mexico	35	NM
New York	36	NY

North Carolina	37	NC
North Dakota	38	ND
Ohio	39	OH
Oregon	41	OR
Pennsylvania	42	PA
Rhode Island	44	RI
South Carolina	45	SC
South Dakota	46	SD
Tennessee	47	TN
Texas	48	TX
Utah	49	UT
Vermont	50	VT
Virginia	51	VA
Washington	53	WA
West Virginia	54	WV
Wisconsin	55	WI
Wyoming	56	WY
Other Outlying Areas		
American Samoa	60	n/a
Federated States of Micronesia	64	n/a
Guam	66	n/a
Marshall Islands	68	n/a
Northern Mariana Islands	69	n/a
Palau	70	n/a
Puerto Rico	72	n/a
Puerto Rico	72	n/a
U.S. Minor Outlying Islands	74	n/a
Virgin Islands of the U.S.	78	n/a
Baker Island	81	n/a
Howland Island	84	n/a
Jarvis Island	86	n/a
Johnston Atoll	67	n/a
Kingman Reef	89	n/a
Midway Islands	71	n/a
Navassa Island	76	n/a
Palmyra Atoll	95	n/a
Wake Island	79	n/a

7. PERFORMANCE MEASURES

The data and the procedures used in developing the ITMS performance measures are discussed in this chapter. Included are discussions of:

- the speed equation and its use in calculating the impact of system changes on lost time due to congestion

- the sources of user costs, such as access time, and access price to the transportation system

- the sources for person and freight movement emissions data

- the multipliers developed to measure the impact of capital and operating expenditures on local and regional economies, both from the perspective of jobs created and as impact on the gross area product

- the sources for accident data

- the five categories of performance measures that were developed, including algorithms.

The first five sections in this chapter discuss sources and base data for the performance measures. The last section addresses the actual performance measure calculations for both person and freight movement.

At the end of this chapter is an example of the performance measures output screens.

1. SPEED EQUATION

The impact of a system change on average travel speed increases the time lost due to congestion. The following equation is used in computing these impacts:

$$\text{Speed} = \frac{FF}{(1 + .15 * (V/C)^4)}$$

where:

Speed: average travel speed, in miles per hour
FF: free flow speed

V: volume
C: capacity.

This equation is the Bureau of Public Roads' standard volume delay function -- also called the capacity restraint function.

2. USER COSTS DATA

Mode shifts occur in ITMS when access or travel price change, and when access time or travel speed change. This section provides documentation for these multiple dimensions of user cost.

The project team developed user costs for all passenger modes to serve as input for ITMS economic performance measures. Two types of costs are used:

- access price, which is the access or terminal cost of trips made (principally parking costs)

- travel price, which is the price per mile traveled, excluding the terminal cost.

For ITMS purposes, the user costs collected represent actual, rather than perceived, costs to the traveling public. The subsidies that support bus or intercity rail transport are not captured in this analysis.

In addition to access and travel price, trip makers are influenced by travel time. For ITMS performance measure calculations, travel time consists of two quantities:

- access time, which is the time required to connect with the mode of travel (sometimes called the wait time), expressed in fractions of an hour

- travel time, which is the time spent in transit on the mode of choice.

For the travel demand models, travel time is calculated directly using speed and distance traveled and therefore, is not discussed further in this section.

All user costs, by mode, are summarized in Exhibit 7-1. For autos, disaggregating cost between urban and rural areas provides further detail. As explained in the section of Chapter 6 that describes the person mode shift model, air trips will not shift based on actions or strategies involving ground based transport systems (i.e., auto, bus, rail). Accordingly, aviation user costs are not developed as base data for the person mode shift model. Finally, appropriate sources are listed as footnotes to Exhibit 7-1.

Exhibit 7-1

User Costs by County, Mode, and Operator

County	Mode	Operator	Peak Access Price PEAK_AP	Peak Access Time PEAK_AT	Peak Travel Price PEAK_TP	Daily Access Price DLY_AP	Daily Access Time DLY_AT	Daily Travel Price DLY_TP
All Counties Not Listed Below	Highways		$ -	3	$ 0.48	$ -	3	$ 0.48
ALA	Bus	Various	$ -	15	$ 0.19	$ -	15	$ 0.19
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
	Pax Rail	BART	$ -	18	$ 0.02	$ -	18	$ 0.02
CC	Bus	Various	$ -	15	$ 0.13	$ -	15	$ 0.13
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
	Pax Rail	BART	$ -	18	$ 0.02	$ -	18	$ 0.02
ED	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
LA	Amtrak	Amtrak	$ -	30	$ 0.17	$ -	30	$ 0.17
	Bus	Various	$ -	15	$ 0.15	$ -	15	$ 0.15
	Highways		$ 9.71	3	$ 0.48	$ 5.83	3	$ 0.48
	Pax Rail	LACMTA	$ -	18	$ 0.03	$ -	18	$ 0.03
	Pax Rail	Metrolink	$ -	20	$ 0.12	$ -	20	$ 0.12
MER	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
MON	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
MRN	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
NAP	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
ORA	Amtrak	Amtrak	$ -	30	$ 0.17	$ -	30	$ 0.17
	Bus	Various	$ -	15	$ 0.15	$ -	15	$ 0.15
	Highways		$ 9.71	3	$ 0.48	$ 9.71	3	$ 0.48
	Pax Rail	Metrolink	$ -	20	$ 0.12	$ -	20	$ 0.12
PLA	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ -	3	$ 0.48	$ -	3	$ 0.48
RIV	Bus	Various	$ -	15	$ 0.09	$ -	15	$ 0.09
	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
	Pax Rail	Metrolink	$ -	20	$ 0.12	$ -	20	$ 0.12
SAC	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ 11.25	3	$ 0.48	$ 5.38	3	$ 0.48
	Pax Rail	Sac RT	$ -	20	$ 0.14	$ -	20	$ 0.14
SB	Amtrak	Amtrak	$ -	30	$ 0.17	$ -	30	$ 0.17
	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
SBD	Bus	Various	$ -	15	$ 0.09	$ -	15	$ 0.09
	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
	Pax Rail	Metrolink	$ -	20	$ 0.12	$ -	20	$ 0.12
SBT	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
SCL	Amtrak	Amtrak	$ -	30	$ 0.17	$ -	30	$ 0.17
	Bus	Various	$ -	15	$ 0.11	$ -	15	$ 0.11
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
	Pax Rail	Caltrain	$ -	10	$ 0.10	$ -	10	$ 0.10
	Pax Rail	SCVTA	$ -	20	$ 0.11	$ -	20	$ 0.11
SCR	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
SD	Amtrak	Amtrak	$ -	30	$ 0.17	$ -	30	$ 0.17
	Bus	Various	$ -	15	$ 0.15	$ -	15	$ 0.15
	Highways		$ 13.50	3	$ 0.48	$ 13.50	3	$ 0.48
	Pax Rail	Coaster	$ -	20	$ 0.13	$ -	16	$ 0.13
	Pax Rail	SDT	$ -	18	$ 0.13	$ -	18	$ 0.13
SF	Bus	Various	$ -	13	$ 0.20	$ -	13	$ 0.20
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
	Pax Rail	BART	$ -	18	$ 0.02	$ -	18	$ 0.02
	Pax Rail	Caltrain	$ -	10	$ 0.10	$ -	10	$ 0.10
	Pax Rail	MUNI	$ -	17	$ 0.22	$ -	17	$ 0.22
SIE	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
SJ	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
SLO	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
SM	Bus	Various	$ -	15	$ 0.09	$ -	15	$ 0.09
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
	Pax Rail	BART	$ -	18	$ 0.02	$ -	18	$ 0.02
	Pax Rail	Caltrain	$ -	10	$ 0.10	$ -	10	$ 0.10
SOL	Bus	Various	$ -	15	$ 0.13	$ -	15	$ 0.13
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
SON	Bus	Various	$ -	15	$ 0.12	$ -	15	$ 0.12
	Highways		$ 6.66	3	$ 0.48	$ 6.66	3	$ 0.48
STA	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
VEN	Amtrak	Amtrak	$ -	30	$ 0.17	$ -	30	$ 0.17
	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ 8.60	3	$ 0.48	$ 8.60	3	$ 0.48
	Pax Rail	Metrolink	$ -	20	$ 0.12	$ -	20	$ 0.12
YOL	Bus	Various	$ -	15	$ 0.14	$ -	15	$ 0.14
	Highways		$ -	3	$ 0.48	$ -	3	$ 0.48

3. EMISSIONS DATA

Base data for the ITMS environmental performance measures were developed for five categories of passenger transport and two categories of freight transport:

- **Passenger**
  - auto
  - bus
  - intercity/commuter rail
  - rail transit (heavy)
  - rail transit (light)

- **Freight**
  - truck
  - rail.

3.1 Mobile Source Emission Rates

The major emission types captured included:

- Hydrocarbons (HC)
- Carbon Monoxide (CO)
- Nitrous oxides (NOx)
- Particulates (PM10).

The project team developed mobile source emission rates for all ITMS horizon years (i.e., 1996, 2006, 2016, 2026). These forecasts take into account the emission control strategies adopted or planned by the California Air Resources Board.

Each category of emissions is discussed below, grouped in the way the data were compiled.

3.1.1 Auto, Bus, and Truck

Auto, bus, and freight truck emission rates were developed based on direct outputs from the Emfac7G model version 1.1 corrected, developed by the California Air Resources Board (CARB). Documentation for the Emfac model can be found at the CARB website: http://www.arb.ca.gov/msei/mvei/mvdocs.htm.

The Emfac7G data developed by the CARB were converted to average grams per mile emission rates for the ITMS horizon years and vehicle types. Key assumptions in this process include:

- Emfac-projected trends for VMT were assumed to continue through the year 2026 (i.e., 2026 VMT estimates were linearly estimated from the 1996-2010 estimates). Note that some vehicle categories, such as non-catalytic and diesel light duty autos, are assumed to continue their downward trend and be absent from the market by that time.

- Autos were interpreted as including all light duty autos, light duty trucks, and medium duty trucks. Emissions were assigned proportionately based on vehicle miles traveled.

- Trucks were interpreted as including all non-catalytic equipped, catalytic equipped, and diesel heavy-duty trucks. Here too emissions were assigned proportionately based on the vehicle miles traveled for each truck sub-class.

- Running losses of 75 degrees F during the summer and 50 degrees F during the winter were added to the exhaust HC emission rates to determine the total HC emissions from the vehicle.

- Running exhaust and running losses were added for appropriate vehicle classes to determine total HC emissions.

- Exhaust particulates and tire wear figures were added to determine total particulate exhaust emissions.

- Results were normalized on an annual basis, using a 60 percent weighting factor for summer data and a 40 percent weighting factor for winter data.

Sample data for 1996 are presented below. Emissions are listed in grams per mile and vehicle speeds are in miles per hour.

Exhibit 7-2
Sample 1996 Emissions Data by Mode and Speed

MPH	HC			CO			NOX			CO2			PM		
	Autos	Bus	Truck	Autos	Bus	Truck	Autos	Bus	Truck	Autos	Bus	Truck	Autos	Bus	Truck
5	4.00	4.87	8.30	31.34	8.53	82.60	1.92	35.48	14.59	1011.43	2123.85	1650.05	0.05	0.80	0.67
10	1.91	3.53	5.57	17.89	5.37	55.54	1.41	27.14	12.69	654.92	2258.38	1780.48	0.05	0.59	0.67
15	1.17	2.66	3.99	12.08	3.59	39.36	1.12	21.82	11.42	472.45	2071.32	1645.99	0.05	0.45	0.67
20	0.84	2.07	3.00	9.13	2.55	29.38	0.94	18.45	10.62	372.12	1871.89	1494.16	0.05	0.36	0.67
25	0.66	1.66	2.35	7.41	1.92	23.11	0.83	16.40	10.16	316.87	1738.15	1391.00	0.05	0.30	0.67
30	0.56	1.39	1.91	6.28	1.54	19.14	0.80	15.32	9.98	288.53	1677.08	1344.11	0.05	0.26	0.67
35	0.47	1.20	1.56	5.46	1.30	16.71	0.82	15.04	10.06	278.00	1685.11	1351.63	0.05	0.23	0.67
40	0.39	1.07	1.36	4.89	1.18	15.36	0.91	15.53	10.37	280.50	1751.54	1405.36	0.05	0.21	0.67
45	0.35	1.00	1.22	4.60	1.13	14.88	1.06	16.86	10.94	293.41	1875.94	1505.07	0.05	0.19	0.67
50	0.34	0.96	1.14	4.72	1.15	15.19	1.27	19.24	11.81	315.24	2034.58	1631.63	0.05	0.19	0.67
55	0.39	0.95	1.09	5.60	1.24	16.35	1.54	23.08	13.08	335.85	2147.66	1720.82	0.05	0.19	0.67
60	0.57	0.98	1.07	8.36	1.42	18.55	1.88	29.11	14.89	353.46	2272.79	1818.45	0.05	0.19	0.67
65	1.27	1.04	1.09	18.04	1.73	22.20	2.27	38.59	17.47	364.14	2476.32	1976.63	0.05	0.20	0.67

3.1.2 Commuter/Intercity and Freight Rail

Commuter and freight rail emission rates were extracted from the CARB 1991 <u>Locomotive Emissions Study</u> (Booz·Allen & Hamilton Inc.). The emission factors contained in the study are the basis for CARB's inventory estimates for locomotives. The freight rail emissions listed are those for mixed freight trains, which are the predominant train service operated in the six basins examined and the largest train type source.

The impact of new state and federal programs to further control NOx and PM emissions from locomotives were considered in developing the forecast emission rates for locomotives. No programs to further control HC and CO emissions are planned, and emission rates for these pollutants are conservatively assumed to stay constant over the study horizon.

Exhibit 7-3
Commuter Rail Emissions

	Emissions, grams per mile			
	HC	CO	NOx	PM
1996	19.73	45.67	666.95	62.02
2006	19.73	45.67	583.58	62.02
2016	19.73	45.67	250.11	31.01
2026	19.73	45.67	250.11	31.01

Exhibit 7-4
Freight Rail Emissions

	Emissions, grams per mile			
	HC	CO	NOx	PM
1996	84.38	271.07	2086.93	154.37
2006	84.38	271.07	1826.07	154.37
2016	84.38	271.07	782.6	77.19
2026	84.38	271.07	2086.93	77.19

3.1.3 Rail Transit

Rail transit emission rates have been subdivided into heavy and light rail. Only the emissions generated from traction power are listed. As the California rail systems operate on electric power, there are no exhaust or evaporative emissions directly emitted by the vehicles. However, the power plants that generate the electricity to propel the rail systems do contribute to the emissions. To estimate the amount of pollution generated by electric power plants, emission factors developed by the CARB for various types of power plants were used.[1] These factors were then adjusted by the control strategies included in the South Coast Air Quality Management District Air Quality Management Plan. These factors were then applied to the power generation mix projected by the California Energy Commission for the State to obtain emission factors in pounds per Megawatt-hour for each of the study years[2] (the power generation mix for 2026 was assumed to be the same as for 2010). To determine emission rates in grams per mile, typical energy consumption rates for transit rail were used. For heavy rail, the energy consumption of the Los Angeles Metro Red Line was used as a representative value. The St. Louis Light Rail System served as the model for other light rail systems. Only the electricity required to provide traction power was included (i.e., the study excluded the electricity to power substations and auxiliary equipment). Study results are presented below.

1 *Draft Technical Support Document for the Low-Emission Vehicle and Zero Emission Vehicle Workshop on March 25, 1994*, *California Air Resources Board.*

2 *Energy and the Economy, California Energy Commission, 1994.*

Exhibit 7-5
Heavy Rail Transit Emissions per Car-Mile

	Emissions, grams per car-mile			
	HC	CO	NOx	PM
1996	0.08	Not Available	5.09	0.22
2006	0.10	N / A	2.01	0.31
2016	0.10	N / A	2.02	0.31
2026	0.10	N / A	2.02	0.31

The car-mile to train-mile conversion is accomplished using average consist sizes in Northern and Southern California. The factors used were six cars per train for heavy rail and three cars per train for light rail.

Exhibit 7-6
Heavy Rail Transit Emissions per Train-Mile

	Emissions, grams per train-mile			
	HC	CO	NOx	PM
1996	0.48	N / A	30.54	1.32
2006	0.60	N / A	12.06	1.86
2016	0.60	N / A	12.06	1.86
2026	0.60	N / A	12.06	1.86

Exhibit 7-7
Light Rail Transit Emissions per Car-Mile

	Emissions, grams per car-mile			
	HC	CO	NOx	PM
1996	0.04	N / A	2.87	0.13
2006	0.06	N / A	1.13	0.17
2016	0.06	N / A	1.14	0.17
2026	0.06	N / A	1.14	0.17

Exhibit 7-8
Light Rail Transit Emissions per Train-Mile

	Emissions, grams per train-mile			
	HC	CO	NOx	PM
1996	0.12	N / A	8.61	0.39
2006	0.18	N / A	3.39	0.51
2016	0.18	N / A	3.42	0.51
2026	0.18	N / A	3.42	0.51

3.2 Fuel Consumption

In this section, fuel economy is defined as the inverse of fuel consumption. Fuel consumption units are gallons per mile; fuel economy units are miles per gallon.

3.2.1 Auto, Bus and Truck

The Emfac7G fuel economy data developed by the CARB in the Impact Rate Report were converted to miles per gallon for the ITMS horizon years and vehicle types. As with the emissions, fuel consumption rates were developed for speeds ranging from 0 to 65 miles per hour. Key assumptions in this process include:

- Emfac-generated fuel economy data for 1996 served as the basis for developing 2006, 2016, and 2026 fuel economy tables.

- For each forecast year, annual fuel economy for each vehicle type was assumed to be consistent across all speeds in the range. Fuel economy figures were then developed based on the percentage fuel economy change from the forecast year to the base year.

- Fuel economy rates were proportionately assigned to ITMS mode types based on vehicle miles traveled (e.g., autos included a weighted average of all light duty autos, light duty trucks and medium trucks; trucks included a weighted average of the three heavy duty truck types).

- Fuel consumption rates, in gallons per mile, were derived based on the fuel economy inverse tables.

Sample data for 1996 and 2006 are presented below in Exhibit 7-9. Fuel consumption rates are listed in gallons per mile.

Exhibit 7-9
Sample Fuel Consumption Data by Mode and Speed (1996 and 2006)

		FUEL CONSUMPTION		
YEAR	MPH	AUTO	BUS	TRUCK
1996	5	0.0462	0.1740	0.1729
1996	10	0.0462	0.1740	0.1728
1996	15	0.0462	0.1733	0.1727
1996	20	0.0462	0.1735	0.1728
1996	25	0.0462	0.1736	0.1729
1996	30	0.0461	0.1737	0.1728
1996	35	0.0461	0.1734	0.1729
1996	40	0.0461	0.1735	0.1729
1996	45	0.0462	0.1736	0.1728
1996	50	0.0462	0.1736	0.1728
1996	55	0.0462	0.1735	0.1728
1996	60	0.0462	0.1735	0.1728
1996	65	0.0462	0.1735	0.1729
2006	5	0.0410	0.1560	0.2766
2006	10	0.0402	0.1550	0.2759
2006	15	0.0404	0.1553	0.2764
2006	20	0.0402	0.1550	0.2764
2006	25	0.0403	0.1552	0.2765
2006	30	0.0402	0.1553	0.2763
2006	35	0.0403	0.1551	0.2763
2006	40	0.0402	0.1553	0.2764
2006	45	0.0403	0.1551	0.2764
2006	50	0.0403	0.1552	0.2764
2006	55	0.0402	0.1553	0.2764
2006	60	0.0403	0.1552	0.2764
2006	65	0.0402	0.1552	0.2763

3.2.2 Commuter/Intercity and Freight Rail

Fuel consumption rates for commuter and freight rail are based on data from the CARB 1991 Locomotive Emissions Study. Unfortunately, the CARB does not forecast fuel consumption for these modes. The project team therefore decided to maintain the fuel consumption rates constant throughout the study horizon. This ensures conservative rates, which are summarized below:

Commuter Rail
Fuel consumption: 3.04 gallons / VMT

Fuel economy: 0.329 miles / gallon

Freight Rail
Fuel consumption: 9.16 gallons / VMT
Fuel economy: 0.109 miles / gallon

3.2.3 Rail Transit

Rail transit vehicles are powered by electricity and were not included in the fuel consumption analysis.

3.3 Carbon Dioxide Emissions

Carbon dioxide (CO_2) results from the combustion of carbon-based fuels. CO_2 represents the primary automotive pollutant contributing to global warming and is considered a "greenhouse gas." Although mobile source emissions have been studied in some detail for some years now, CO_2 emissions have not been modeled with the same rigor. The methodology the project team adopted in deriving CO_2 emission rates has been to research or, in some cases, develop equations that relate the carbon content of the fuel with its carbon emissions.

3.3.1 Autos

For gasoline, the equation to determine fuel economy is provided by:

$$FE = \frac{2421}{(0.273\, CO_2 + 0.866\, HC + 0.429\, CO)}$$

where:

FE: fuel economy, miles per gallon
HC: HC emissions, grams per mile
CO: CO emissions, grams per mile
CO_2: CO_2 emissions, grams per mile.

CO_2 emission rates can easily be determined, since all other quantities are known. Hence,

$$CO_2 = 8868 / FE - 3.17 * HC - 1.57 * CO$$

The formula was then applied to emissions and fuel consumption rates developed earlier. Results are shown below, in Exhibit 7-10, for 1996 and 2006.

Exhibit 7-10
Sample Carbon Dioxide Emissions by Mode and Speed

		CO2 EMISSIONS		
YEAR	MPH	AUTO	BUS	TRUCK
1996	5	1011.43	2123.85	1650.05
1996	10	654.92	2258.38	1780.48
1996	15	472.45	2071.32	1645.99
1996	20	372.12	1871.89	1494.16
1996	25	316.87	1738.15	1391.00
1996	30	288.53	1677.08	1344.11
1996	35	278.00	1685.11	1351.63
1996	40	280.50	1751.54	1405.36
1996	45	293.41	1875.94	1505.07
1996	50	315.24	2034.58	1631.63
1996	55	335.85	2147.66	1720.82
1996	60	353.46	2272.79	1818.45
1996	65	364.14	2476.32	1976.63
2006	5	950.08	3728.63	1737.63
2006	10	618.63	6626.28	1863.97
2006	15	444.70	7743.17	1704.70
2006	20	349.06	8046.44	1537.56
2006	25	296.14	8147.93	1423.71
2006	30	268.80	8291.21	1367.15
2006	35	258.38	8741.42	1375.80
2006	40	260.32	9365.50	1429.20
2006	45	272.17		1530.59
2006	50	292.53		1656.32
2006	55	311.23		1743.33
2006	60	326.93		1817.86
2006	65	335.88		1883.22

3.3.2 Buses, Trucks, Passenger Rail, Freight Rail

The development of an equation for CO_2 emissions related to diesel fuel is fairly straightforward. One must consider the following:

- carbon coefficient for distillate fuel (diesel) = 19.77 million metric tons per quadrillion BTU[3]

- 1 gallon diesel = 138,700 Gross BTU[4]

Combustion of one gallon of diesel hence produces 2,742 grams of carbon.

Carbon emissions for diesel fuel are then equated with carbon emissions for diesel exhaust, based on the molecular weight (MW) relationships shown in Exhibit 7-11.

Exhibit 7-11
Carbon Concentration by ITMS Pollutant

	Total MW	Carbon MW	Percent Carbon
HC	13.825	12.011	86.88
CO	28.011	12.011	42.88
CO_2	44.011	12.011	27.29

By balancing the carbon weights, the general equation follows:

$$2742 \text{ gC} * \text{FuelCons} = (\%C * HC) + (\%C * CO) + (\%C * CO_2)$$

where:

FuelCons: fuel consumption, gallons of diesel per mile
HC: HC emissions, grams per mile
CO: CO emissions, grams per mile
CO_2: CO_2 emissions, grams per mile.

Hence,

$$CO_2 = 10048 * \text{FuelCons} - 3.18 * HC - 1.57 * CO$$

The formula was then applied to emissions and fuel consumption rates developed earlier. Results are summarized above, in Exhibit 7-9, for 1996 and 2006.

In order to determine HC and CO rates, average speeds of 20 and 35 miles per hour were selected for buses and heavy-duty trucks, respectively.

The results for the different modes are presented in Exhibit 7-12.

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3 *Emissions of Greenhouse Gases in the United States 1985-1990, Energy Information Administration, September 1993.*

4 *Transportation Energy Data Book, 14th Edition, Oak Ridge National Laboratory, May 1994.*

Exhibit 7-12
Carbon Dioxide Emissions per Mile

CO_2 Emissions, grams per mile				
	Bus	Truck	Commuter Rail	Freight Rail
1996	1,753	1,773	30,460	91,377
2006	1,550	1,590	30,460	91,377
2016	1,449	1,592	30,460	91,377
2026	1,348	1,492	30,460	91,377

3.3.3 Rail Transit

CO_2 emissions for rail transit were developed based on data from "Changing by Degrees, Steps to Reduce Greenhouse Emissions," U.S. Congress, Office of Technology Assessment, February 1991. The emissions captured stem from the power plants.

Exhibit 7-13
Carbon Dioxide Emissions per Car-Mile

CO_2 Emissions, grams per car-mile		
	Heavy Rail	Light Rail
1996	2,843	1,603
2006	3,107	1,752
2016	3,109	1,798
2026	3,189	1,798

The car-mile to train-mile conversion is accomplished using average consist sizes, similar to the process undertaken for the other emissions.

Exhibit 7-14
Carbon Dioxide Emissions per Train-Mile

CO_2 Emissions, grams per train-mile		
	Heavy Rail	Light Rail
1996	17,058	4,809
2006	18,642	5,256
2016	18,654	5,394
2026	18,654	5,394

4. ECONOMIC INDICATORS

Multipliers were developed to measure the impact of capital and operating expenditures on the local and regional economies. The multipliers define the number of jobs created by direct and indirect capital and operating expenditures and the amount of increase in gross area product resulting from these expenditures.

These impacts differ by mode and by place, because the amount of imported materials used in construction differ by mode. For example, railway locomotives are made outside California, whereas most materials for highways can be obtained within the state. The magnitude of multipliers also varies with the size and character of the region, with larger impacts in urban areas than in rural areas.

The empirical basis for the construction of the multipliers was the project team's prior use of the REMI model in the Los Angeles area to estimate transportation impacts. The results were updated with current statistics on Gross State Product generated by the California Department of Finance.

The following were the primary sources used in the development of the economic indicators:

- Regional Economic Models, Inc., "REMI Model"
- Los Angeles County Transportation Commission, *Regional Economic Analysis of the 30-Year Plan*, prepared by Booz·Allen & Hamilton, 1992
- University of California, Los Angeles, *The UCLA Business Forecast for California* (quarterly).

The REMI model, as applied to the LACTC study, produced the following employment multipliers: 37.9 (per million dollars of capital expenditures); 37.6 (per million dollars of operating expenditures). The UCLA source lists a $52,000 increase in gross area product (for the state) for every job increase. All multipliers are summarized below (units are jobs or GAP impact per million dollars invested).

Employment Multipliers		GAP Multipliers	
Capital	Operating	Capital	Operating
37.9	37.6	37.9*52,000	37.6*52,000

5. ACCIDENT DATA

For purposes of intermodal comparison, the accident frequency data was standardized across modes. Two factors were selected:

- frequency of accidents per passenger mile of travel (PMT) for people movement

- frequency of accidents per ton mile of freight hauled for goods movement.

Passenger miles of travel by mode and ton miles of freight hauled by mode were obtained from the U.S. Department of Transportation's annual publication, National Transportation Statistics.

Accidents were categorized by accident occurrence, injury accidents, and fatal accidents. These data were obtained from several sources, but primarily from the U.S. Department of Transportation's Transportation Safety Information Report.

The frequency factors were obtained by dividing the passenger and ton miles traveled by the number of accidents by mode of transport.

Information concerning the costs of accidents and fatalities (for purposes of cost/benefit analysis) was obtained from the National Safety Council.

6. PERFORMANCE MEASURE CALCULATIONS

This section describes the performance measures that are calculated after the demand models (i.e., person mode choice model and the freight flow processor, if selected) have run. Exhibit 7-15 and 16, at the end of this chapter, shows the different performance measures that the ITMS calculates and displays.

Performance measures are only calculated under the "Evaluation" option of the ITMS menu. Performance measures can be calculated for actions or strategies (i.e., a series of actions). In addition, evaluation options also include comparing two actions and comparing two scenarios. This document does not address action or scenario evaluation comparisons.

All performance measures are calculated by C programs:

- mobility measures (e.g., mobility index, lost time due to congestion)
- financial performance measures (e.g., annual equivalent cost or AEC)

- environmental performance measures (e.g., air pollution, fuel consumption)
- economic performance measures (e.g., jobs supported, gross area product impacts)
- safety performance measures (e.g., number of accidents).

Before detailing the methodology and functional specifications for calculating performance measures, it is important to note the following:

- Performance measure results will always reflect the net change compared to the base case. Therefore, the C programs that process the person mode choice algorithms store the original values of the fields. For instance, to calculate the "lost time to congestion" performance measure, we present the net changes in lost time due to congestion as a result of a given action or strategy.

- Performance measures use data in the Action Attribute File, the Other Modal Attribute File and the Action Description File. In addition, they will sometimes also access reference tables to perform certain calculations (e.g., to calculate environmental measures such as air pollution, programs will access the air pollution reference table).

- All files accessed are in .dbf format.

The remainder of this section describes the "big picture" process for performance measure calculations, and then presents the detailed algorithms for each measure and the files and fields that contain the variables in the algorithms.

6.1 Process

The overall process goes from AVENUE-based GUI to person mode choice model and, if selected, the freight flow processor to performance measure calculation and finally back to AVENUE.

The demand models (person mode choice model and the freight flow processor) calculate new values for fields in the modal attribute files (including the action attribute file). The performance measure models then calculate the measures by comparing these new values to the original values per the different algorithms. The performance measure models then produce an output file with the results and pass on the file to the AVENUE programs for presentation to the user.

6.2 Mobility Performance Measures

Mobility performance measures include:

- The Mobility Index
- Lost Time.

6.2.1 The Mobility Index

The following steps calculate the person mobility index (MI) impacts:

Step 1 - calculate the original MI as follows:

$$OMIP = PMT1 / VMT1 * MPH1$$

where:

OMIP	=	original mobility index
PMT1	=	original person miles traveled
VMT1	=	original vehicle miles traveled
MPH1	=	original weighted average speed (weighted by PMT)

Step 2 - calculate the new MI as follows:

$$NMIP = PMT2 / VMT2 * MPH2$$

where:

NMIP	=	new mobility index for the person market
PMT2	=	new person miles traveled
VMT2	=	new vehicle miles traveled
MPH2	=	new weighted average speed (weighted by PMT)

Step 3 - calculate the net difference in MI:

for person market: $NDMIP = NMIP - OMIP$

where:

NDMIP	=	net difference in mobility index for the person market
NMIP	=	new mobility index for the person market
OMIP	=	original mobility index for the person market
NDMIF	=	net difference in mobility index for the freight market

Step 4 - calculate the percent difference in MI:

for person market: PDMIP = NMIP / OMIP - 1

where:

PDMIP	=	percent difference in mobility index for the person market
NMIP	=	new mobility index for the person market
OMIP	=	original mobility index for the person market

Step 5 - write results of steps 2, 3 and 4 into an output file.

6.2.2 Lost Time

Lost time represents the incremental time required to transport people and goods compared to free flow speeds. The following steps calculate change in lost time:

Step 1 - calculate original lost time:

for person market: OLTP = PMT1 / MPH1 - PMT1 / POSTED

where:

OLTP	=	original lost time for the person market
PMT1	=	original passenger miles traveled
MPH1	=	original speed
POSTED	=	posted speed

Step 2 - calculate new lost time:

for person market: NLTP = PMT2 / MPH2-PMT2 / POSTED

where:

NLTP	=	new lost time for the person market
PMT2	=	new passenger miles traveled
MPH2	=	new speed
POSTED	=	posted speed

Step 3 - calculate net change in lost time:

for person market: NCLTP = NLTP - OLTP

where:

NCLTP	=	net change in lost time for the person market
NLTP	=	new lost time for the person market
OLTP	=	original lost time for the person market

Step 4 - calculate percent change in lost time:

for person market: PCLTP = NLTP / OLTP - 1

where:

PCLTP	=	percent change in lost time for the person market
NLTP	=	new lost time for the person market
OLTP	=	original lost time for the person market

Step 5 - write the results of steps 2, 3, and 4 into an output file.

6.3 Financial Performance Measures

Financial performance measures include the cost to the service provider and user costs.

6.3.1 Cost to Service Provider

Under ITMS, each time the user constructs an action, he or she will have the option to provide capital and operating costs, as well as the estimated project useful life. This data entering process will place under the ITMS Action Screen.

The performance measure for the cost to service provider is provided by the following algorithm:

$$AEC = \sum(CapCost_i \;/\; ULife_i) + \sum OpCost_i \quad \text{for } i=1,n$$

where:

AEC	=	annual equivalent cost
CapCost	=	capital cost
ULife	=	useful life
OpCost	=	annual operating cost
i	=	transportation project
n	=	number of projects

If the evaluation applies to one action only, the user cost to service providers will reflect the net sum of the cost to service providers for each individual action. For a strategy involving several actions, the user cost will reflect the net sum of the user costs for each individual action.

6.3.2 User Costs

The user costs defined in section 2 include access price and travel price. Each cost was tabulated for competing modes in the person mode shift model. Performance measures for person modes are calculated as follows:

$$OUCost = \Sigma\ ((VMT_i * TP_i) + AP_i) \quad \text{for } i=1,n$$

for auto

$$OUCost = \Sigma\ ((PMT_i * TP_i) + AP_i) \quad \text{for } i=1,n$$

for other modes

where:

OUCost = original user cost
PMT = person miles traveled
VMT = vehicle miles traveled
TP = travel price
AP = access price
n = number of modes

Once an action is made, a new set of user cost characteristics can be calculated:

$$NUCost = \Sigma\ ((PMT_i * TP_i) + AP_i) \quad \text{for } i=1,n$$

for non-auto or

$$NUCost = \Sigma\ ((VMT_i * TP_i) + AP_i) \quad \text{for } i=1,n$$

for auto

where:

NUCost = new user cost
PMT = person miles traveled
TP = travel price
AP = access price

n = number of modes

The net user cost can then easily be computed by taking the difference between the original and new user costs:

NetUCost = NUCost - OUCost

where:

NetUCost = net user cost
NUCost = new user cost
OUCost = original user cost

6.4 Environmental Performance Measures

Environmental performance measures are by far the most complex since they require the programs to access several reference files. Environmental measures include air pollution, fuel consumption, and carbon dioxide emissions. All these measures should reflect net changes.

These three measures are functions of which mode (e.g., car, bus, truck, rail) is influenced, the impacts on speed of each mode and the total number of vehicles for each mode. The environmental measures can be calculated by accessing a number of tables and performing a number of algorithms as follows:

- for auto, bus, and trucks, look-up tables derived from the California EMFAC7 model are used; the look-up tables contain emission rates (e.g., grams per mile) for different speeds as well as fuel consumption rates

- for commuter, inter-city, and freight rail, simpler look-up tables are used which contain one line of emission rates and fuel consumption rates

- to calculate carbon dioxide (green house gases), a straight formula is used that converts fuel consumption into CO2. The formula is slightly different for gasoline and diesel fuels.

The modes included in the action/strategy modal attribute files are:

- auto
- bus
- commuter rail
- heavy (transit) rail
- light (transit) rail

- freight rail
- freight truck.

Each of these modes entails a different analysis.

6.4.1 Auto, Bus or Truck

Each mode has a different set of look-up tables, but the process is the same.

Step 1 - locate beginning emission rates using look-up tables and MPH1 for the given mode as follows:

OERate=LRate + (MPH1-LMPH)*(HRate-LRate)/*(HMPH-LMPH)

where:

OERate	=	original emission rate
MPH1	=	original speed
HMPH	=	closest higher speed in look-up table
LMPH	=	closest lower speed in look-up table
LRate	=	emission rate for closest lower speed
HRate	=	emission rate for closest higher speed.

Example: To locate emission rates for an original speed of 32 miles per hour (i.e., MPH1=32mph):

The emission table will have several lines similar to the following:

Speed	CO
5	33
10	18
15	12
20	9
25	8
30	7
35	6
40	5
45	5
50	5
55	6
60	9
65	22

In this case, since we are looking for the rate for MPH1 = 32mph, LMPH or the closest lower speed is 30 mph and HMPH is 35 mph. Consequently LRate = 7, HRate = 6 and OERate = 7 + (32 - 30) * (6 - 7) / (35 - 40). Therefore OERate = 6.6. This constitutes a straight line interpolation between the two nearest values.

Note that this process will be repeated for each emission type, including Carbon Monoxide (CO), Hydrocarbons (HC), Nitrogen Oxides (NOX), and Particulate Matter (PM10). The same method will also be applied to calculate fuel consumption rates.

Step 2 - calculate beginning emission inventory as follows:

TOE = sum (OER_i*LEN*VOL1) for i=1,n

where:

TOE	=	total original emissions
OER	=	original emission rate
LEN	=	length of the segment
VOL1	=	beginning number of vehicles at the segment level
n	=	number of emission types.

Step 3 - calculate beginning fuel consumption as follows:

OTF = OFCRate*LEN*VOL1

where:

OTF	=	original total fuel
OFCRate	=	original fuel consumption rate
LEN	=	length of the segment
VOL1	=	beginning number of vehicles at the segment level.

Step 4 - calculate beginning carbon dioxide emissions as follows:

OERate(CO2) = 8868*OFCRate - 3.17*OERate(HC) - 1.57*OERate(CO)

where:

OERate(CO2)	=	original CO2 emission rate
OFCRate	=	original fuel consumption rate
OERate(HC)	=	original HC emission rate
OERate(CO)	=	original CO emission rate.

For buses and trucks, the formula is slightly different because diesel fuel CO2 exhaust characteristics are different:

OERate(CO2) = 10048*OFCRate - 3.18*OERate(HC) - 1.57*OERate(CO)

Step 5 - locate ending emission rates using look-up tables for auto and MPH2 as before:

NERrate = LRate + (MPH2 - LMPH) * (HRate - LRate) / (HMPH - LMPH)

where:

NERate	=	new emission rate
MPH2	=	new speed
HMPH	=	closest higher speed in look-up table
LMPH	=	closest lower speed in look-up table
LRate	=	emission rate for closest lower speed
HRate	=	emission rate for closest higher speed.

This process will be repeated for each emission type and for fuel consumption as before.

Step 6 - calculate new emission inventory as follows:

TNE = sum ($NERate_i$*LEN*VOL1) for i=1,n

where:

TNE	=	total new emissions
NERate	=	new emission rate
LEN	=	length of segment
VOL1	=	beginning number of vehicles at the segment level

n	=	number of emission types.

Step 7 - calculate new fuel consumption as follows:

NTF = NCRate*LEN*VOL2

where:

NTF	=	new total fuel
NFCRate	=	new fuel consumption rate
LEN	=	the length of the segment
VOL2	=	the new number of vehicles at the segment level.

Step 8 - calculate new carbon dioxide emissions as follows:

NERate(CO2) = LRate(CO2) + (HRate(CO2)-LRate(CO2))*(HMPH-LMPH)

where:

NERate(CO2)	=	new CO2 emission rate
LRate(CO2)	=	CO2 emission rate for closest lower speed
HRate(CO2)	=	CO2 emission rate for closest higher speed
HMPH	=	closest higher speed in look-up table
LMPH	=	closest lower speed in look-up table.

6.4.2 Commuter Rail, Freight Rail, Rail Transit

Each mode has its own look-up table, but the process is the same, except that the two rail transit modes (i.e., light rail and heavy rail) do not consume fuel.

Step 1 - calculate original emissions as follows:

OE = sum of (TRAINS * LEN * $ERate_i$) for i=1,n

where:

OE	=	original emissions
TRAINS	=	number of trains at the segment level
LEN	=	length of the segment
ERate	=	emission rate
n	=	number of emission types.

Step 2 - calculate original fuel consumption as follows:

OFC = TRAINS * LEN * FCRate

where:

OFC	=	original fuel consumption
TRAINS	=	number of trains at the segment level
LEN	=	length of the segment
FCRate	=	fuel consumption rate.

Step 3 - calculate change in emissions as follows:

CE = OE * PMT2 / PMT1

where:

CE	=	change in emissions
OE	=	original emissions
PMT2	=	new person miles traveled
PMT1	=	original person miles traveled.

Step 4 - calculate change in fuel consumption as follows:

CFC = OFC * PMT2 / PMT1

where:

CFC	=	change in fuel consumption
OFC	=	original fuel consumption
PMT2	=	new person miles traveled
PMT1	=	original person miles traveled.

6.5 Economic Performance Measures

Economic performance measures fall into two categories: employment supported measures (jobs supported); and gross area product (GAP) impacts.

6.5.1 Employment Supported Measures

Based on the multipliers developed in section 4, the number of new jobs created per period will be slightly different depending on whether the investment consisted of capital or operating funds. For capital funds:

NJCap= EmpCapMult * CapInv

where

NJCap = number of new jobs created by transportation capital investment
CapInv = capital investment in millions of dollars
EmpCapMult employment capital multiplier

For operating funds:

NJOp= EmpOpMult * OpInv

where

NJO = number of new jobs created by transportation operating investment
OpInv = operating investment in millions of dollars
EmpOpMult employment operating multiplier

6.5.2 Gross Area Impacts

GAP impacts can similarly be calculated based on the multipliers developed for capital and operating funded projects. For the capital investment portion of a project:

GAPCap= EmpCapMult * AvgWage * CapInv

where

GAPCap = gross area product created by transportation capital investment
CapInv = capital investment in millions of dollars
EmpCapMult=employment capital multiplier
AvgWage= average annual wage

For operating projects:

GAPOp= EmpOpMult* AvgWage * OpInv

where

GAPOp = gross area product created by transportation operating investment
OpInv = operating investment in millions of dollars
EmpOpMult= employment operating multiplier
AvgWage= average annual wage

6.6 Safety Performance Measures

Annual accident statistics data have provided three categories of safety data from which safety performance measures can be developed:

- Total Accident Rate
- Accidents involving injuries
- Accidents involving fatalities

For each mode, there is an overall accident rate, an injury rate and a fatality rate. The performance measures shown by ITMS use these trend averages and do not predict actual accidents. Rather, they calculate the total accidents based on accident rate trends per mode as follows:

TA = Arate*VMT

where:

TA	Total Accidents for each mode
Arate	Accident Rates for each mode
VMT	Vehicle Miles Traveled

Again, the output is not specific to the geography or to the given geometric characteristics. Rather, it is an overall trend output. For more detailed accident information, please refer to the California Safety Management System.

Exhibit 7-15
Performance Measures And Data Needs

(Page 1 of 2)

PERSON MOVEMENT							
Performance Measure Group	**Measure**	**Formula**	**Data Needed by Modal Source**				
			Highway	**Air**	**Rail**	**Water**	**Transit**
Mobility	Mobility Index	PMT/VMT x Avg. Speed	Vehicles, distance, Speed, Occupancy	Vehicles, distance, Speed, Occupancy	Vehicles, distance, Speed, Occupancy	Vehicles, distance, Speed, Occupancy	Vehicles, distance, Speed, Occupancy
	Level of Service Link	Volume / Capacity	Highway demand, lanes	N/A	track v. #tracks	N/A	Passengers Seats
	Lost Time	Actual time - Theoretical time	Actual Speeds, Posted speeds	N/A	Free Flow travel time, actual travel time	N/A	Actual Speeds, Posted speeds
Financial	Cost to Service Provider	$\left(\frac{\text{Capital Costs}}{\text{Useful Life}} + \text{Annual Operating Costs}\right) / \text{Person Miles}$	Maint., repair, liability, capital, operating, depreciation	Fuel, Maint., repair, liability, capital, operating, depreciation	Fuel, Maint., repair, liability, capital, operating, depreciation	Fuel, Maint., repair, liability, capital, operating, depreciation	Fuel, Maint., repair, liability, capital, operating, depreciation
	User costs	User costs / person miles	fuel, insurance, repairs, maint., capital, depreciation	Fares	Fares	Fares	Fares
Environmental	Pollution	pollution / person miles	Pollutants, distance, persons	Pollutants, distance, persons	Pollutants, distance, persons	Pollutants, distance, persons	Pollutants, distance, persons
	Green House Emissions	CO_2 / person miles	CO_2 / person miles	CO_2 / person miles	CO_2 / person miles	CO_2 / person miles	CO_2 / person miles
	Fuel con-sumption	fuel / person miles	fuel / person miles	fuel / person miles	fuel / person miles	fuel / person miles	fuel / person miles

* N/A - Not Applicable

Exhibit 7-15
Performance Measures And Data Needs

(Page 2 of 2)

PERSON MOVEMENT							
Performance Measure Group	**Measure**	**Formula**	**Data Needed by Modal Source**				
			Highway	**Air**	**Rail**	**Water**	**Transit**
Economic	Avg. Jobs supported per year	$\frac{\text{Capital Costs}}{\text{Useful Life}} * \text{Capital Employment Multiplier} + \text{Annual Operating Costs} * \text{Operating Employment Mutliplier}$	operating expenditures, capital costs, useful life, employment multipliers	operating expenditures, capital costs, useful life, employment multipliers	operating expenditures, capital costs, useful life, employment multipliers	operating expenditures, capital costs, useful life, employment multipliers	operating expenditures, capital costs, useful life, employment multipliers
	GSP Impacts	$\frac{\text{Capital Costs}}{\text{Useful Life}} * \text{Capital GSP Multiplier} + \text{Annual Operating Costs} * \text{Operating GSP Mutliplier}$	operating expenditures, capital costs, useful life, GSP multipliers	operating expenditures, capital costs, useful life, GSP multipliers	operating expenditures, capital costs, useful life, GSP multipliers	operating expenditures, capital costs, useful life, GSP multipliers	operating expenditures, capital costs, useful life, GSP multipliers
Safety	Accidents	Accidents / person mile	Accidents, person miles	Accidents, person miles	Accidents, person miles	Accidents, person miles	Accidents, person miles

* N/A - Not Applicable

Exhibit 7-16
(Page 1 of 5)
Evaluation Output Screens

ACTION NAME:
DESCRIPTION:

PERFORMANCE MEASURES

I. PERSON TRAVEL MARKET

IA. MOBILITY MEASURES:

		DAILY	PEAK
TOTAL PMT IMPACTED	=	______	______
TOTAL VMT IMPACTED	=	______	______

PERSON THROUGHPUT (or MOBILITY INDEX)		DAILY	PEAK
BEFORE	=	______	______
AFTER	=	______	______
DIFFERENCE	=	______	______
PERCENT DIFFERENCE	=	______	______

LOST TIME DUE TO CONGESTION (in hours)		DAILY	PEAK
BEFORE	=	______	______
AFTER	=	______	______
DIFFERENCE	=	______	______
PERCENT DIFFERENCE	=	______	______

IB. FINANCIAL MEASURES

COST TO SERVICE PROVIDERS (in dollars)

CAPITAL COSTS	=	______
OPERATING COSTS	=	______
ANNUAL EQUIVALENT COSTS	=	______
AEC PER 1000 DAILY PMT	=	______

USER COSTS		DAILY	PEAK
NET CHANGE	=	______	______
NET CHANGE PER 1000 PMT	=	______	______

Exhibit 7-16
(Page 2 of 5)
Evaluation Output Screens

IC. ENVIRONMENTAL MEASURES

NET CHANGES TO RUNNING EMISSIONS (in lbs)		DAILY	PEAK
CARBON MONOXIDE	=	______	______
HYDRO CARBONS	=	______	______
NITROGEN OXIDES	=	______	______
PARTICULATE MATTER	=	______	______
TOTAL CHANGE	=	______	______
CHANGE PER 1000 PMT	=	______	______

NET CHANGES TO FUEL CONSUMPTION (in gallons)		DAILY	PEAK
NET CHANGE	=	______	______
NET CHANGE PER 1000 PMT	=	______	______

NET CHANGES TO GREEN HOUSE GAS EMISSIONS (CARBON DIOXIDE in lbs)		DAILY	PEAK
NET CHANGE	=	______	______
NET CHANGE PER 1000 PMT	=	______	______

ID. ECONOMIC MEASURES

JOBS SUPPORTED VIA

CAPITAL SPENT = ______

OPERATING SPENT = ______

GROSS AREA PRODUCT IMPACTS VIA

CAPITAL SPENT = ______

OPERATING SPENT = ______

Exhibit 7-16
(Page 3 of 5)
Evaluation Output Screens

IE. SAFETY MEASURES (in daily accidents based on statewide trend averages)

BEFORE

ACCIDENTS	=	________________
DEATHS	=	________________
INJURIES	=	________________

AFTER

ACCIDENTS	=	________________
DEATHS	=	________________
INJURIES	=	________________

DIFFERENCE

ACCIDENTS	=	________________
DEATHS	=	________________
INJURIES	=	________________

Exhibit 7-16
(Page 4 of 5)
Evaluation Output Screens

II. FREIGHT AND GOODS MOVEMENT MARKET

		DAILY
TOTAL CALIFORNIA TON MILES IMPACTED	=	______

IIA. MOBILITY MEASURES:

FREIGHT THROUGHPUT (or MOBILITY INDEX)		DAILY
BEFORE	=	______
AFTER	=	______
DIFFERENCE	=	______
PERCENT DIFFERENCE	=	______
LOST TIME DUE TO CONGESTION (in hours)		DAILY
BEFORE	=	______
AFTER	=	______
DIFFERENCE	=	______
PERCENT DIFFERENCE	=	______

IIB. FINANCIAL MEASURES

USER COSTS		DAILY
NET CHANGE	=	______
NET CHANGE PER 1000 TON MILES	=	______

Exhibit 7-16
(Page 5 of 5)
Evaluation Output Screens

IIC. ENVIRONMENTAL MEASURES

NET CHANGES TO RUNNING EMISSIONS (in lbs)		DAILY
CARBON MONOXIDE	=	____________
HYDRO CARBONS	=	____________
NITROGEN OXIDES	=	____________
PARTICULATE MATTER	=	____________
TOTAL CHANGE	=	____________
CHANGE PER 1000 TON MILES	=	____________

NET CHANGES TO FUEL CONSUMPTION (in gallons)		DAILY
TOTAL CHANGE	=	____________
CHANGE PER 1000 TON MILES	=	____________

NET CHANGES TO GREEN HOUSE GAS EMISSIONS (CARBON DIOXIDE in lbs)		DAILY
TOTAL CHANGE	=	____________
CHANGE PER 1000 TON MILES	=	____________